CITY OF TURLOCK
STANISLAUS COUNTY, CALIFORNIA

CONTRACT DOCUMENTS
FOR
CONSTRUCTION OF THE
HARDING DRAIN BYPASS PUMP
STATION AND PIPELINE PROJECT

PROJECT NO. WQCF-6859

MAY 2012
CONFORMED

VOLUME 3
Specifications
(Divisions 10 through 17)

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Project Manager: Darren Baune, P.E.
CITY OF TURLOCK
STANISLAUS COUNTY, CALIFORNIA

HARDING DRAIN BYPASS PUMP STATION AND PIPELINE PROJECT
LICENSEE RESPONSIBLE FOR SPECIFICATIONS

Contract Documents prepared by or under the direction of the following registered persons:

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CITY OF TURLOCK

HARDING DRAIN BYPASS PUMP STATION
AND PIPELINE PROJECT

PROJECT NO. WQCF-6859

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IDENTIFICATION DEVICES

PART 1   GENERAL

1.01 SUMMARY

A. Section Includes: Plastic and metal signs for building and site use.

B. Related Sections:
   1. Section 16075 - Electrical Identification

1.02 SUBMITTALS

A. Product Data.

B. Shop Drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's Installation Instructions.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer Qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.


PART 2   PRODUCTS

2.01 PLASTIC SIGNAGE SYSTEM

A. Manufacturers:
   1. One of the following or equal:
      a. Best Manufacturing Sign Systems, Montrose, CO; System 900013.
      b. Andco Industries Corp., Greensboro, NC; equivalent product.
      c. Vomar Products, Inc., Sepulveda, CA; equivalent product.

B. Attachment:
   1. Vinyl Tape, self-adhering.
C. Lettering:

D. Material for Interior Use:
   1. Plastic 1/8 inch thick raised letters.

E. Material for Exterior Use:
   1. Fiberglass 1/4 inch thick with high gloss finish, raised letters.

F. Colors:
   1. As selected by ENGINEER from manufacturer's standard colors.

G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

2.02 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40 mil thick aluminum with baked enamel finish. One of the following or equal:
   2. Emedco, Buffalo, New York

B. Danger Sign Colors:
   2. Heading: White lettering on red oval with white border in black rectangular panel.
   4. Size: As scheduled.

C. Caution Sign Colors:
   1. Background: Yellow.
   2. Heading: Yellow lettering on black rectangular panel.
   4. Size: As scheduled.

D. Safety Instruction Signs:
   2. Heading: White lettering on green rectangular panel.
   4. Size: As scheduled.

E. Warning Sign Colors:
   1. Background: Orange.
   2. Heading: Black lettering on orange diamond in black rectangular panel.
   4. Size: As scheduled.

F. Notice Information Signs:
   2. Heading: White lettering on blue rectangular panel.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.
H. See Schedule B for specific sign size, location, text, and quantity.

2.03 EXTERIOR INFORMATION SIGNS

A. Able to Withstand 100 mph Wind Load Without Damage.
   1. Manufacturers: One of the following or equal:
      b. Andco Industries Corp.; Greensboro, NC; equivalent product.
      c. Vomar Products, Inc.; Sepulveda, CA; equivalent product.

B. Sign Panel: Nominal 3 inches thick, consisting of 1/8 inch thick fiberglass material
   with integral returns fully encapsulating wood and foam core, 1/8 inch radius edges
   and corners, size as indicated on the Drawings.

C. Text: Helvetica Medium, size and wording as indicated on the Drawings.

D. Posts: Nominal 3 inch square extruded aluminum sections with aluminum fillers at
   top and bottom, mounting hardware, and aluminum baseplates drilled for anchor
   bolts.

E. Fasteners: Manufacturer's standard, suitable for application.

F. Colors: As selected from manufacturer's standard colors.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs where indicated on the Drawings or as indicated in the following
   schedules.

3.03 SCHEDULES

A. Plastic Signage System Schedule.

B. Metal Safety Sign Schedule.

END OF SECTION
SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Fire Extinguishers:
   1. Location:  Adjacent to fire extinguishers.
   2. Height:  60 inches above floor to center of sign.
   5. Text:  FIRE EXTINGUISHER.

END OF SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE
SCHEDULE B

METAL SAFETY SIGN SCHEDULE

A. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically by remote control.
   2. Height: In accordance with Typical Details.
   3. Size: 10" wide, 7-inches high.
   4. Heading: DANGER
   5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY BY REMOTE CONTROL

B. HIGH VOLTAGE WARNING:
   1. Location: On front and back of electrical equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
   2. Height: In accordance with Typical Details.
   3. Size: 10" wide, 7-inches high.
   4. Heading: DANGER
   5. Wording: HIGH VOLTAGE KEEP OUT

C. DANGER DROWNING HAZARD
   1. Location: At standpipe stairs
   2. Size: 12" x 12"
   3. Heading: DANGER
   4. Wording: Drowning Hazard. DO NOT ENTER STANDPIPE.

D. DANGER SUBMERGED OUTFALL
   1. Location: At river outfall
   2. Size: 24" x 24"
   3. Heading: DANGER
   4. Submerged outfall. Large rocks may be submerged when river is HIGH.

E. LOCKOUT STATION
   1. Location: Pump room
   2. Size: As required
   3. Heading: LOCK OUT STATION
   4. Accessories:
      a. 5 padlocks and keys
      b. 1 bag of lock out tags

END OF SCHEDULE B
METAL SAFETY SIGN SCHEDULE
SCHEDULE C

OUTDOOR SIGNAGE

A. NO TRESSPASSING: CITY OF TURLOCK PROPERTY VIOLATORS WILL BE PROSECUTED
   1. Location: On north, south, east and western fences at standpipe and pump station
   2. Height: 6’ mounted on the fence.
   3. Size: 12” x 12:
   4. Heading: No trespassing.
   5. CITY OF TURLOCK PROPERTY, VIOLATION WILL BE PROSECUTED.
SECTION 10520
FIRE PROTECTION SPECIALTIES

PART 1   GENERAL

1.01  SUMMARY
   A.  Section Includes: Fire extinguishers and cabinets.

1.02  SUBMITTALS
   A.  Product Data.

   B.  Manufacturer's Installation Instructions.

1.03  QUALITY ASSURANCE
   A.  Manufacturer Qualifications: Manufacturer of proposed products for minimum
       5 years with satisfactory performance record of minimum 5 years.

   B.  Regulatory Requirements:
       1.  Comply with UL requirements for classification type.
       2.  Provide fire rated cabinet tubs where required to maintain fire rating of walls.

1.04  LOCATION OF FIRE EXTINGUISHER
   A.  Locate one fire extinguisher in each of the following rooms:
       1.  Pump Station Electrical Room.
       2.  Pump Station Pump Room.

1.05  MAINTENANCE
   A.  Extra Materials: Furnish and install minimum 10 percent, but not less than one, of
       fire extinguishers with brackets installed in addition to the number indicated on the
       Drawings.

PART 2   PRODUCTS

2.01  MANUFACTURERS
   A.  Fire Extinguisher and Cabinets: One of the following or equal:
       1.  J.L. Industries, Bloomington, MN.
       2.  Larsen's Manufacturing Company, Minneapolis, MN.
       3.  Modern Metal Products by Muckle, Owatonna, MN.
       4.  Watrous, Incorporated, Northbrook, IL.
2.02 FIRE EXTINGUISHERS

A. Type FE05: UL 2A:10B:C with 5 pound capacity of dry chemical with ammonium phosphate base for extinguishing ABC fires.

B. Type FE10: UL 4A:60B:C with 10 pound capacity of dry chemical with ammonium phosphate base for extinguishing ABC fires.

C. Type FE20: UL 20A: 120B:C with 20 pound capacity of dry chemical with ammonium phosphate base for extinguishing ABC fires.

D. Type EFE10: UL 1A:10B:C with 10 pound capacity of colorless, odor less, electrically non-conductive liquefied gas, or clean agent as defined by NFPA 2001, for extinguishing electrical fires without leaving residue.

E. Type EFE15: UL 2A;10B:C with 15 pound capacity of colorless, odor less, electrically non-conductive liquefied gas, or clean agent as defined by NFPA 2001, for extinguishing electrical fires without leaving residue.

2.03 WALL BRACKETS

A. Type: Standard as manufactured by fire extinguisher manufacturer.

2.04 FIRE EXTINGUISHER CABINETS

A. Manufacturers: One of the following or equal:
   1. J. L. Industries.

B. Cabinets: Surface mounted as indicated; stainless steel at wet areas, steel elsewhere:
   1. Tub:
      a. Trim: Recessed, 1-1/4 inch face trim.
      b. Material: Cold-rolled steel.
      c. Finish: Semi-gloss epoxy, white.

C. Door:
   1. Type: Clear Vu Series.
   2. Style: Full acrylic.
   4. Stiles and Rails: 1 inch wide.
   5. Metal Material: Same as for Tub.
   6. Metal Finish: Same as for Tub.
   7. Pull: Manufacturer's standard.

2.05 OPERATING HARDWARE

A. Hinges: Continuous heavy duty hinge.

B. Lock:
   1. 5 pin-tumbler Special Purpose Cabinet Lock with solid cam that will not break or bend away. Key shall be removable in locked position only.
2.06 ACCESSORIES

A. Extinguisher Brackets: Formed steel, corrosion resistant finish, size and type to suit extinguisher.

B. Cabinet Signage: Black painted lettering, one inch high, indicating cabinet function; "FIRE EXTINGUISHER" or "FIRE HOSE" as appropriate. Place lettering vertically on hinge side of door.

C. Cabinet Mounting Hardware: Appropriate to cabinet.

D. Fasteners: Fasteners exposed in the final installation, with the door open and closed, shall be tamper-proof fasteners.

2.07 FABRICATION

A. Form cabinet enclosure with right angle inside corners and seams. Form perimeter trim.

B. Pre-drill for anchors.

C. Hinge doors for 180 degree opening.

D. Weld, fill, and grind components smooth.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer’s recommendations.

B. Install products plumb, square and level.

C. Place Extinguishers: Locate one extinguisher in each cabinet and elsewhere as indicated.

3.02 SCHEDULE

A. Install fire extinguisher on wall brackets when fire extinguisher are indicated without cabinets.

B. Install fire extinguisher in cabinets when fire extinguisher cabinets are indicated.

C. Install three fire extinguishers with brackets where directed by the ENGINEER.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fully functional package booster pump system with constant speed drive, pneumatic tank, centrifugal pump, and specified appurtenances.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 01756 - Testing, Training, and Facility Start-up.
      d. Section 15958 - Mechanical Equipment Testing
      e. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. ASTM International (ASTM):
   2. B 62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

1.03 SYSTEM DESCRIPTION

A. Booster Pump System requirements:
   1. The Booster Pump System shall be a fully functional package system capable of supplying the specified flow and pressure. All components of the system shall be mounted on an integral pneumatic tank.
   2. Design system to provide 60 psi total head while supplying a minimum flow rate of 28 gallons per minute.
   3. Provide one pump sized for a minimum of 28 gallons per minute at 60 psi.
   4. Provide diaphragm pneumatic tank with bladder system suitable for operation at the specified flow rate and pressure.
   5. Provide an analog pressure gauge on booster pump system discharge.
6. Provide an automatic pressure switch to operate the pump and maintain system pressure.
7. Provide a pressure relief valve to prevent over pressurization.
8. Provide a check valve to prevent backflow through the pump.

B. Required appurtenances
   1. Provide a hose, hose rack, and a spray nozzle for a fully functional washdown station.

1.04 SUBMITTALS
A. General: Submit as specified in Section 01330.
B. Product data:
   1. Catalog information describing pumps, valves, tanks, electrical components, appurtenances, and other products incorporated into the system.
C. Schematic of piping, equipment and other appurtenances prior to installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Booster Pump System: One of the following or equal:
   1. Towle Whitney, TW1000-CS-1.5.

2.02 PUMPS
A. Type: Constant speed, multi-stage, horizontal centrifugal type.
B. Construction:
   1. All parts in contact with the pumped liquid shall be stainless steel.

2.03 MOTORS
A. Motors:
   1. 208 volt, 1 phase, 60 hertz, 3,500 revolutions per minute.
   2. Totally enclosed, fan cooled enclosure (TEFC).
   3. As specified in Section 16222.
2.04 PNEUMATIC TANK

A. Tank shall include a fully integrated bladder system to maintain constant pressure output and prevent the motor from excessive start/stops.

B. Tank construction:
   1. Coated steel tank.
   2. Integral Buna-N rubber bladder system to prevent contact between the pumped fluid and the steel tank.

C. Size: As required for proper system operation.

2.05 APPURTENANCES

A. Hose Rack:
   1. Wall Mounted hoserack
      a. Provide a stainless steel hose rack with the ability to hold 100 feet of hose. Provide wall mounted hose rack where shown on the drawings.
      b. Manufacturers: One of the following or equal
         1) Strahman Valve, HR 100L for wall mounted applications
         2) Armstrong International, Model 41R.
      c. Provide bolts to mount the hoserack to wall.

B. Hose
   1. Design:
      a. At each hose rack provide flexible, extruded high pressure hot water hose with 3/4" Female NPT fitting on unit end with 5/8" Swivel Adapter on the other (user) end.
      b. Pressure rating: 300 psi
      c. Temperature Rating: -20 F – 200 F
      d. Fittings: Bronze
      e. Hose material: Neoprene or acceptable oil resistant material suitable for a working pressure of minimum 120 pounds per square inch, gauge.
   2. Manufacture:
      a. Strahman Valve
      b. Goodyear Rubber Products Corp.
      c. Uniroyal.
      d. Goodall Rubber Company.

C. Nozzle:
   1. Design
      a. Maximum Working Pressure: 150 psi
      b. Body: Stainless Steel
      c. Rubber coating
      d. Flow Rate: 10 gpm
   2. Manufacture:
      a. Strahman Valve, S-70
      b. Armstrong Internation, Model 038
PART 3  EXECUTION

3.01  INSTALLATION

A. Install equipment and piping in accordance with manufacturers instructions.

B. Install equipment as specified in Sections 01612 and 05120.

3.02  FIELD QUALITY CONTROL

A. Following installation, make necessary adjustments and perform functional testing as specified in Sections 01756 and 15958.
### 3.03 SCHEDULE

<table>
<thead>
<tr>
<th>Tag Numbers</th>
<th>OPS-PUM-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Type</td>
<td>Constant Speed Motor</td>
</tr>
<tr>
<td>Rated Design Point</td>
<td></td>
</tr>
<tr>
<td>Flow, gpm</td>
<td>28</td>
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<tr>
<td>Head, psi</td>
<td>60</td>
</tr>
<tr>
<td>Max Pump Speed</td>
<td>3,500</td>
</tr>
<tr>
<td>Min Motor Horsepower</td>
<td>1.5</td>
</tr>
</tbody>
</table>

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure washing station and accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.

1.02 SUBMITTALS

A. General: Submit as specified in Section 01330.

B. Operation and Maintenance Manual.

PART 2 PRODUCTS

2.01 PRESSURE WASHER

A. Provide 1 wheel mounted gas powered pressure washer. The pressure washer shall come with 100 foot hose, single wand spray gun, and quick connect hosing.

B. The pressure washer shall meet the following requirements:
   1. Pressure: 4200 psi
   2. Flow rate: 4 gpm
   3. 1 year warranty

C. Manufactures: DeWalt DPW4240 Professional Pressure Washer or equal.

2.02 HOSE RACK

A. Provide a stainless steel hose rack with the ability to hold 100 feet of hose. Provide wall mounted hose rack where directed by the engineer.

B. Manufactures: One of the following or equal:
1. Strahman Valve, HR 100L for wall mounted applications
2. Armstrong International, Model 41R.

C. Provide bolts to mount the hoserack to wall.

2.03 VALVES AND HOSES

A. Ball valve connection: Contractor is to provide 3/8-inch hose and valve connections that shall attach to the 2-inch ball valve connection located underneath pump discharge piping. Contractor to provide all connections required for a fully working wash-down system.

B. Contractor to provide two coils of 100-foot 3/8-inch hose.

PART 3 EXECUTION

3.01 INSTALLATION

A. Contractor is to provide a new pressure washer at the end of the project and all connections required to thread into one of the 2-inch ball valves located underneath the pump discharge piping.

END OF SECTION
SECTION 11292A

FLAP GATES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Framed flap gates.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      b. Section 09960 - Coatings.

1.02 REFERENCES

A. ASTM International (ASTM):

1.03 DESIGN REQUIREMENTS

A. Flap gates shall open when there is a differential pressure across the flap of 0.2 feet or less.

B. With the flap gate submerged, the head loss shall not exceed 0.3 feet at all existing velocities for gates 60 inches or smaller.

C. Design to meet seating pressures listed in Flap Gate Schedule.

1.04 SUBMITTALS

A. Product data.

B. Shop drawings.
C. Manufacturer’s installation instructions.

D. Design data and calculations substantiating conformance with the drawings and Specifications.

E. Manufacturer shall certify in writing that installed flap gates meet specified leakage and headloss requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Waterman Industries.
   2. Hydrogate Corporation.

B. Anchor bolts and wall thimbles: Provided by flap gate manufacturer.

2.02 MATERIALS

A. Cast iron: ASTM A 126, Class B ASTM, A 48, Class 30.

B. Bronze:
   1. Bronze subject to submersion or splash: Not more than 6 percent zinc and no aluminum.

C. Stainless steel: ASTM A 276, Type 304, 304L, 316, or 316L.


2.03 GATE COMPONENTS

A. Body frame and cover: Material as specified in Flap Gate Schedule.
   1. Frame:
      a. Size as specified in the Flap Gate Schedule.
      b. Mount as specified in the Flap Gate Schedule.
   2. Cover:
      a. Cast in one piece or welded and shall be of a dished or reinforced design to maximize strength, rigidity, and minimize weight.
      b. Cast a lifting eye at the top of the cover for manual operation.

B. Seats: Material as specified in Flap Gate Schedule.

C. Hinge arms:
   1. Double pivot-point design:
      a. The lower pivot shall allow the cover and the frame to lie in the same plane.
      b. The upper pivot shall be adjustable to vary sensitivity to unseating heads.
D. Hinge pins: Material as specified in Flap Gate Schedule.
E. Bolts, nuts, and fittings: Type 316 stainless steel.

2.04 WALL THIMBLES

A. F-section of a depth equal to the thickness of the structure wall upon which the gate is mounted.
   1. Modify when required for pipe connections in a wall.
      a. Provide a flange-by-mechanical joint wall thimble where ductile iron piping connects to the wall thimble.
      b. Provide flange-by-bell ring wall thimble insert where reinforced concrete piping connects to the wall thimble.

B. Material: Cast iron of sufficient section to resist permanent distortion due to casting and installation stresses.

C. Width of mounting flange of wall thimble: 1/2-inch wider than mounting flange of gate.

D. Machine front flange, drill, and tap to match drilling on gate frame.

E. Mark top center of each thimble.

F. Provide stainless steel studs for attaching the gate frame.

G. Seal joint between thimble and gate frame watertight.

H. To permit entrapped air to escape as the thimble is being cast in concrete, cast or drill holes in each entrapment zone formed by ribs, flanges, and water stops.

2.05 ANCHOR BOLTS

A. When required, hooked end type, of sufficient quantity and length to anchor the gate.

B. Material: Type 316 stainless steel.

2.06 COATING

A. Coat flap gates in the factory prior to testing.

B. Coat with surface tolerant high solids epoxy. As specified in Section 09960.

C. Repair or touch-up damaged areas of the factory applied coating in the field.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.
B. Mount thimbles and gates plumb in both vertical planes and level in horizontal plane.

C. Provide factory-trained personnel to:
   1. Check the complete installation.
   2. Make necessary adjustments.
   3. Conduct field-testing.

D. Coat seating surfaces between frame and wall thimble with a waterproof plastic compound prior to tightening of frame studs.

3.02 FIELD QUALITY CONTROL

A. Testing:
   1. Leakage tests: Demonstrate compliance with allowable leakage limits set forth herein.
   2. After the gate installation and checking, exercise each gate from the closed position to fully open position and back to the closed position at least twice and verify gate is properly seated.
   3. Provide certificate of proper installation. As specified in Section 01756.

3.03 FLAP GATE SCHEDULE

A. The Flap Gate Schedule is not a gate take-off list.

<table>
<thead>
<tr>
<th>Opening Size &amp; Service</th>
<th>Reference Drawing</th>
<th>Frame &amp; Gate Material</th>
<th>Type of Closure</th>
<th>Hinge Arm Material</th>
<th>Hinge Pin Material</th>
<th>Wall Thimble</th>
<th>Design Pressure, Seating</th>
</tr>
</thead>
<tbody>
<tr>
<td>48&quot; FE</td>
<td>RDS-5</td>
<td>Cast Iron</td>
<td>Flatback</td>
<td>Galvanized Steel</td>
<td>304 L Stainless</td>
<td>F-Type</td>
<td>15 ft</td>
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</tbody>
</table>

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Cast-iron slide gates.

B. Related Sections:
   2. Section 09960 - Coatings.
   3. Section 13446 - Valve and Gate Operators.

1.02 REFERENCES

A. American Water Works Association (AWWA):

B. ASTM International (ASTM):
   6. B 139 - Specification for Phosphor Bronze Rod, Bar and Shapes.

1.03 DEFINITIONS

A. Slenderness Ratio: The largest ratio obtained by dividing the unsupported length of the stem by the radius of gyration of the stem cross section.

1.04 DESIGN REQUIREMENTS

A. Conform to AWWA C 560, as complemented and modified herein.

B. Design to meet seating and unseating pressures listed in Cast Iron Slide Gate Schedule.

C. Gate Components:
   1. Slide and Guides: Design for minimum safety factor of 5 with regard to tensile, compressive, and shear strength.
   2. Lifts, General: Provide tandem lifts with interconnecting shaft on all gates with an aspect ratio (width divided by height) equal to or exceeding 2.0.
   3. Stem: Select stem diameter, stem guide quantity and stem guide spacing based on following criteria:
b. Tensile Strength: Suitable to withstand the force generated by the operator with the application of a 200 pound force applied to the crank or handwheel or a 250 foot-pound torque applied to the wrench nut.
c. Compressive Strength: Suitable to withstand buckling due to the force generated by the operator with the application of an 80 pound force applied to the crank or handwheel or a 100 foot-pound torque applied to the wrench nut. Determine buckling load using Euler Column formula defined in AWWA C 560.
4. Thrust Nut: Suitable to withstand thrust developed by operator with the application of a 40 pound force on the crank or handwheel with safety factor of
5. Yokes for Self-contained Gates:
   a. Design yoke using design loading criteria for stem.
   b. Maximum Deflection at Design Load: Not to exceed 1/360th of the span.

1.05 SUBMITTALS
A. Layout and installation drawings for each gate size and type.
B. Wall thimbles.
C. Manufacturer's installation instructions.
D. Design Calculations: Calculations and design data substantiating conformance with the drawings and specifications.
E. Operation and Maintenance Manuals.

1.06 QUALITY ASSURANCE
A. Factory Markings:
   1. Mark gates according to the schedule numbers when such numbers are used.
   2. Where thimbles, frames, and other components are not interchangeable, match mark components.
B. Manufacturer Qualifications:
   1. Experience in production of substantially similar equipment during the 5 years prior to issuance of this contract, and able to submit evidence of satisfactory operation in at least 5 different installations.

PART 2 PRODUCT

2.01 MANUFACTURER
A. One of the following or equal:
   1. Rodney Hunt Company.
   2. Hydrogate.
   3. Waterman.
B. Operators, Anchor Bolts, and Wall Thimbles: Provided by cast iron slide gate manufacturer.
2.02 MATERIALS


B. Bronze:
   1. Bronze Subject to Submersion or Splash: Not more than 6 percent zinc and no aluminum.
   3. Phosphor Bronze: ASTM B 139, UNS Number C51000.
   4. Silicon Bronze: ASTM B 584 UNS Number C87300.

C. Galvanized Structural Steel: ASTM A36, Galvanized per ASTM A123.

D. Stainless Steel: ASTM A 276, Type 316 or Type 304.


2.03 COMPONENTS

A. Slide:
   1. Cast iron.
   2. 1-piece with integrally cast vertical and horizontal ribs.
   3. Machined dovetail grooves on the seat surfaces into which is forced a Type 304 stainless steel seat facing, machine-finished in accordance with AWWA C 560, after installation in the slide.
   5. Integrally cast wedge pads machined to receive wedges.
   6. Reinforced thrust nut pocket cast integrally on front face above horizontal center, shape as required to receive thrust nut, and with provisions for drainage of pocket.

B. Frame:
   1. Cast iron, 1-piece.
   2. Flanged back section with rectangular, square, or round opening as indicated on the Drawings.
   3. Machined dovetail grooves on the front face into which is forced a type 304 stainless steel seat facing,machined in accordance with AWWA C 560, after installation in the frame.
   4. Machine surfaces which contact slide and wall thimble.

C. Guides:
   1. Cast iron, 1-piece.
   2. Attachment to frame:
      a. Cast integrally with frame.
   3. Length: Sufficient to retain at least half the height of the slide in the full open position.
   4. Grooves for tongues on slide:
      a. Full length of guide.
      b. Machined on all contact surfaces.
      c. Maximum 1/16-inch clearance between tongue and groove wall.
D. Wedges and Wedge Seats:
   1. Sufficient quantity to result in full contact between slide and frame when slide is in closed position and subjected to design pressure specified in slide gate schedules.
   2. Locations:
      a. Both vertical sides.
      b. Top and Bottom: When gates 24 inches or more in width are subject to unseating head conditions.
   3. Wedges:
      a. Adjustable to allow alignment with seat.
      b. Type 316 stainless steel with machined mating and contact surfaces.
      c. Type 316 stainless steel holddown bolt.
      d. Stainless steel adjustment bolt and lock nut that allows proper field adjustment and permanently maintains position of wedge after final adjustment.
      e. Side Wedges: Keyed and bolted to machined pads on slide.
      f. Top and Bottom Wedges: Hook shaped and bolted to machine pads on slide.
   4. Wedge Seats:
      a. Side Wedges Seats:
         1) Gates Smaller than 54 Inches: Keyed and bolted to machined pad on guide.
         2) Gates 54 Inches and Larger: Integrally cast with guide and machined to match wedge face. Provide support ribs on guide at each seat location to resist wedging forces.
      b. Top and Bottom Wedge Seats:
         1) Keyed to prevent movement under force.
         2) Attach to frame with 2 type 316 stainless steel bolts.
         3) Machined contact surfaces.

E. Stem:
   1. Type 316 stainless steel.
   2. Machine cut or rolled threads.
   3. Stem Couplings:
      a. Silicon Bronze.
      b. Threaded and keyed to stem or threaded and bolted to stem.
   4. Stem Guides:
      a. Cast iron.
      b. Split collar.
      c. Adjustable in 2 directions.
      d. Silicon bronze bushings.
   5. Provide manganese bronze stop collar on stem above actuator.
   6. Connect stem to slide with thrust nut and nut pocket.

F. Thrust Nut:
   1. Silicon bronze.
   2. Construct thrust nut and slide to prevent turning of thrust nut in the thrust nut pocket.
   3. Rising-stem Gates: Thread and key, or thread and pin thrust nut to stem.

G. Bolts, Nuts, and Fittings: Type 316 stainless steel.
H. Anchor Bolts:
   1. Type 316 stainless steel.
   2. Hooked end type.

2.04 SLIDE GATES WITH FLUSH BOTTOM CLOSURE

A. Conform to Requirements for Cast-iron slide Gates and Following Additional Provisions:
   1. Provide gates designed for flush bottom seal with a strip of neoprene along the bottom of the gate frame or slide.
   2. Accomplish sealing action when the gate is closed by contact and compression of the neoprene seal between the gate slide and the gate frame.
   3. Seal Retainer Bar: Type 316 stainless steel.
   4. When seal is on slide, provide machined cast-iron stop bar attached to frame.

2.05 WALL THIMBLES

A. F-section, of a depth equal to the thickness of the structure wall upon which the gate is mounted.
   1. Modify when required for pipe connections in a wall.
      a. Provide a flange-by-mechanical joint or flange-by-push on joint wall thimble where ductile iron piping connects to the wall thimble. Restrain piping to wall thimble where required.
      b. Provide flange-by-bell ring wall thimble insert where reinforced concrete piping connects to the wall thimble.
   B. Cast iron of sufficient section to resist permanent distortion due to casting and installation stresses.
   C. Width of Mounting Flange of Wall Thimble: 1/2 inch wider than mounting flange of gate.
   D. Machine front flange, drill, and tap to match drilling on gate frame.
   E. Mark top center of each thimble.
   F. Provide stainless steel studs for attaching the gate frame.
   G. Seal joint between thimble and gate watertight, in accordance with AWWA C 560.
   H. To permit entrapped air to escape as the thimble is being cast in concrete, cast or drill holes in each entrapment zone formed by ribs, flanges, and water stops.

2.06 ANCHOR BOLTS

A. Hooked end type, of sufficient quantity and length to anchor the unit.
B. Material: Type 316 stainless steel.

2.07 COATING

A. Coat slide gates in the factory, prior to testing.
B. Coat with surface tolerant high solids epoxy. Comply with Section 09960.
C. Repair or touch-up damaged areas of the factory applied coating in the field.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to manufacturer's installation instructions.

B. Mount thimbles and gates plumb in both vertical planes and level in horizontal plane.

C. Provide Certified, Factory-Trained Personnel to:
   1. Check the complete installation.
   2. Make necessary adjustments.
   3. Conduct field testing.
   4. Conduct any required operator training.

D. Coat seating surfaces between frame and wall thimble with a waterproof plastic compound prior to tightening of frame studs.

E. Adjust wedges or other parts of the gate to the point where it will not be possible to insert a 0.004-inch feeler gauge between the gate slide and the gate frame at any point. Securely lock wedges into position after adjustment.

F. Adjust limit switches in electrical and hydraulic operators in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Testing:
   2. After the gate installation and checking, run gates through at least 2 full cycles from the closed position to fully open position and back to the closed position.

3.03 CAST IRON SLIDE GATE SCHEDULE

A. The Cast Iron Slide Gate Schedule is provided as a reference and not as a gate take-off list.
<table>
<thead>
<tr>
<th>Opening Size</th>
<th>Opening Shape</th>
<th>Seating Head</th>
<th>Unseating Head</th>
<th>Wall Thimble</th>
<th>Type of Closure</th>
<th>Operator Mounting</th>
<th>Operator Type</th>
<th>Service</th>
<th>Stem Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>48&quot;(1)</td>
<td>Circular</td>
<td>15 ft,</td>
<td>39 ft</td>
<td>Type F/ Wall Pipe</td>
<td>Flush Bottom</td>
<td>Pedestal Mount</td>
<td>Manual</td>
<td>Open/Close</td>
<td>Rising Stem</td>
<td>See Spec 13446 for Actuator Requirements</td>
</tr>
</tbody>
</table>

Notes:
(1) Nominal diameter, verify outside/inside diameter with pipe manufacturer prior to fabrication.

END OF SECTION
SECTION 11312D
VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Pump systems including vertical turbine pumps with radial-closed type
      impellers and drivers as scheduled.

B. Related Sections:
   1. Section 01140 - Work Restrictions.
   2. Section 01330 - Submittal Procedures.
   3. Section 01600 - Product Requirements.
   5. Section 09960A - High Performance Coatings.
   6. Section 15050 - Basic Mechanical Materials and Methods.
   8. Section 16222 - Motors.
   9. Section 16264 – Variable Frequency Drive 60-500 Horsepower.
   10. Section 13410 - Basic Measurement and Control Instrumentation Materials
       and Methods.
   11. Section 13411 - Control Strategies.
   12. Section 16264 - Variable Frequency Drives 100 Horsepower and Above.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125,
      250, and 300.
   2. ASME B 16.5 - Pipe Flanges and Flanged Fittings.

B. American Society for Testing and Materials (ASTM):
   2. A 53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated,
      Welded and Seamless.
      Plate, Sheet, and Strip.
   5. A 176 - Specification for Stainless and Heat-Resisting Chromium Steel Plate,
      Sheet and Strip.
   7. A 283 - Specification for Low and Intermediate Tensile Strength Carbon Steel
      Plates.
   9. A 582 - Specification for Free-Machining Stainless and Heat-Resisting Steel
      Bars.
      Corrosion Resistant, for General Application.

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

D. American National Standards Institute/Hydraulic Institute (ANSI/HI):
   1. 2.1-2.5 - Vertical Pumps - Nomenclature, Definitions, Application and Operation.
   2. 3.6 - Vertical Pump Tests.
   3. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application and Sound Measurement.

E. International Standards Organization (ISO):
   1. ISO 9001 Certified.

1.03 DEFINITIONS

A. Pump head (total dynamic head), flow capacity, pump efficiency, net positive suction head available and net positive suction head required are as defined in ANSI/HI 2.1-2.5 and 9.1-9.5 and as modified in the Specifications.

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 2.1-2.2, 2.3, 2.6, and 9.1-9.5 and as modified in the Specifications. The pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge.

B. Flow, head, efficiency and motor horsepower specified in this section are minimums unless stated otherwise.

C. Suction Head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.

D. Tolerances: This Section and related sections contain tolerances that may be more stringent than Hydraulic Institute Standard tolerances. Where tolerances are not mentioned, Hydraulic Institute Standards 2.1-2.2, 2.3, 2.4, and 9.1-9.5 shall apply.

1.04 SYSTEM DESCRIPTION

A. Components: Pump, motors, and drive arrangements as specified or as scheduled with shafts, columns, intermediate bearings, seals, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.
B. Design Requirements:
   1. Pump Performance Characteristics:
      a. As specified in the Pump Schedule.
      b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.

1.05 SUBMITTALS

A. Provide submittals as specified in Section 15050, subsection 1.05 plus the following:
   1. Pump Torsional Analysis.
   2. Critical Speed Analysis.
   3. Quality control test results as specified in Section 15958 when scheduled.
   4. Show shaft diameter and bearing spacing on shop drawings. Submit calculations showing shaft critical frequency and determination of bearing spacings.
   5. Submit pump curves on which the specified operating points are marked. Show efficiency and brake horsepower for the selected pump curve. Include moment of inertia of the impeller and liquid. Show required submergence and NPSH.
   6. As part of the test procedure for the pumps, record measurements for the impeller adjustment and total lateral shaft deflection (shaft runout) above the stuffing box.
   7. Submit detailed instructions for modification of the bowl/impeller assembly to meet the future performance conditions.

B. Anchor bolt calculations. An approved submittal will not be issued until submitted anchor bolt calculations stamped by an engineer registered in the State of California have been accepted. See specification sections 01612 and 15050 for additional requirements.

1.06 QUALITY ASSURANCE

A. General: As specified in Section 15050.

B. Provide pumps specified in this Section from same manufacturer. Require pump manufacturer to furnish and coordinate pump, driver, drive, and pump components as scheduled and to provide written installation and check out requirements.

C. Pump manufacturer must be ISO 9001 certified and present proof of ISO 9001 certification with manufacturer submittals. Non ISO 9001 certified pumps will not be considered as an “or equal.”

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 15050.

1.08 DESIGN REQUIREMENTS

A. Range of Pumping Conditions: Pumps shall operate satisfactorily over the range of pumping conditions scheduled.
B. The pump manufacturer shall perform a lateral and torsional critical speed analysis of the complete electrical and mechanical equipment drive train that includes the motor, shafts, couplings, and bowl assembly demonstrating that the lateral and torsional critical speeds are avoided through the pump's complete operational speed range:
   1. The analysis shall be performed by a qualified and experienced analyst with at least 5 years of recent direct experience in doing the type of analysis required.
   2. The analysis shall be performed in accordance with the methods described in API 541 for dynamic analysis and shall include vane pass frequencies of the pump.
   3. The electrical and mechanical equipment drive train shall be designed so that the train's first lateral and torsional critical speeds are at least 20 percent above the maximum scheduled pump speed and the drive train's second lateral and torsional critical speeds are at least 10 percent above or below any possible excitation frequency within the pump's scheduled operating speed range.
   4. As a Minimum, the Following shall be Submitted for Review:
      a. Description of the method used to calculate the lateral and torsional critical speeds.
      b. Diagram of the mass elastic system used in the analysis.
      c. Table of the mass moment and torsional stiffness of each element of the mass elastic system.
      d. Campbell or Interference Diagram showing plots of critical speeds vs. pump rotational speeds.

C. If either the train's lateral or torsional critical speeds fall within the separation margins specified the pump vendor shall perform a stress analysis at no extra cost to the OWNER to demonstrate that the resonant frequencies have no adverse effect on any element of the train or any element foundation or support in terms of overstress, shortened life due to fatigue, excessive deflection, and/or reduced bearing life. The magnitude of excitation and degree of damping used in the stress analysis shall be clearly stated and agreed to by the ENGINEER before submitting the final analysis. A mode shape diagram showing peak stresses for each resonant frequency shall be provided along with a fatigue and deflection analysis of the affected item(s), and a revised calculation of bearing

1.09 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions as specified in Section 01140.

1.10 WARRANTY

A. As specified in Section 15050.

1.11 MAINTENANCE

A. Special Tools:
   1. Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.
2. Deliver any special tools required to install the pump impeller/bowl assembly to meet the future conditions listed in the pump schedule.

B. Spare Parts: Deliver the following spare parts to OWNER; pack and label for storage.
   1. Line Shaft Bronze Bearings: One set for each type pump.
   2. Impeller and Bowl Wear Rings: One set for each type of pump.
   3. Mechanical Seal: Two of each type supplied for each pump.
   4. Tension Nut Assembly: Provide two complete assemblies.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Weir-Floway
   2. Fairbanks Morse.
   3. Flowserve.

2.02 MATERIALS

A. General: Materials in the Pump Schedule shall be the type and grade as specified in this Article.

B. Cast Iron: ASTM A 48, Class 30 minimum.

C. Nickel Cast Iron: ANSI/ASTM A 48, minimum Class 30, cast iron with 3 percent nickel.


E. Iron-Chromium Alloy: ASTM A 743, Grade CA40; ASTM A 276, Type 420 Stainless Steel may be substituted; Brinell Hardness Number of 350 to 380.

F. Leaded Tin Bronze: ASTM B 505, Alloy C92700.

G. Bronze or High Lead Tin Bronze: ASTM B 584, Alloy 93800.


I. 416 Stainless: ASTM A 582, Type 416 Stainless Steel.

J. Neoprene: Polychloroprene rubber.

K. Steel Plates: ASTM A 283, Grade B.

L. Steel Pipe: ASTM A 53, Grade B.

M. Structural Steel: ASTM A36.


O. 405 Stainless: ASTM A 276, Type 405.
2.03 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, vertical turbine, centrifugal type pumps meeting performance requirements and features as scheduled and as specified.

B. Discharge Flange: Dimensions shall be for an AWWA Class D flange rated for 150 psi. Flange face shall be flat.

C. Discharge Nozzles: Provide 1/2 inch NPT taps for pressure gauges; install nipple and gauge with block valve.

D. Bearings: Design driver/motor bearings to support the line shaft assembly and rated for ABMA L10 life of 60,000 hours at Rated Design Point flow and head in accordance with ABMA 9 or ABMA 11. Design motor thrust bearing to withstand continuous duty full load down thrust and momentary up thrust equivalent to at least 30 percent of the maximum down thrust that may occur during pump on/off or other operations.

E. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

2.04 PUMP SUCTION ASSEMBLY

A. Pump Suction Assembly: Provide suction bell and anti-vortex baffles. Design suction bells and anti-vortex baffles to minimize solids plugging and vortexing. Provide suction bell with eyebolts or lifting lugs for handling.

B. Materials:
   1. Pump Suction Bell: As scheduled
   2. Anti-Vortex Baffles: Same material as scheduled for pump suction bell.
   3. Pump Suction Bell Bearing: As scheduled.

2.05 PUMP IMPELLER BOWL ASSEMBLIES

A. Pump Impeller Assembly:
   1. Type: As scheduled.
   2. Maximum Number of Vanes: As scheduled.
   3. Number of Stages: As scheduled.
   4. Required Balance: As specified in Section 15050 to meet vibration criteria as specified in Section 15958.
   5. Method of Securing Impellers to Shafts: Keyed and secured by a bronze nut locked in place or locked by other methods acceptable to the ENGINEER. Provide any special tools required for removal and installation of pump impellers.
   6. Provisions for Adjustment of Axial Clearance: Make such adjustment through use of motor adjusting nut or adjustable coupling.
   7. Impeller Thrust: When appropriate for the specified impeller type, provide hydraulically balanced impeller to minimize down thrust.

B. Intermediate and Discharge Impeller Cases:
   1. Material: As scheduled.
   2. Attached with bolting.
C. Pump Impeller Bowl Bearings: Provide bearing for each impeller; material as scheduled.

D. Diffusion Vanes: Provide vanes cast into bowl.

E. Suction Bowl Bearings: Provide bronze sleeved bearings with self contained lubrication system filled with graphite type non-soluble grease; provide bearing with sand cap.

F. Design with smooth water passages to reduce clogging by stringy or fibrous materials on impellers or shafting.

G. Design replaceable wear rings for both the bowl and impeller on each impeller bowl. Bowl and impeller wear rings will be of different materials and shall have a Brinell Hardness difference of at least 50.

H. Design capable of passing solids with a sphere size as scheduled or larger.

I. Provide each bowl with eyebolts or lugs for handling.

2.06 LINE SHAFTS

A. Provide line shaft type and lubrication type as scheduled and as specified in this sub-section.

B. Enclosed line shaft, oil lubricated:
   1. Shaft and couplings: Provide flanged shaft couplings with key or set screw locking of shaft couplings.
   2. Shaft bearings and spiders: Provide bearings and retainers as scheduled, but not to exceed 10 feet and enclosing tube spiders spaced at 30 feet maximum; provide oil reservoir volume for 3 days continuous use.
   3. Enclosing tube: Pipe, thickness as scheduled.
   4. Materials: As scheduled; when not scheduled provide:
      a. Shaft and couplings: ASTM A 108, Grade 1045 steel with ASTM A 276, Type 316 hardened stainless steel journal or sleeve at each bearing.
      b. Shaft bearings and spiders: ASTM B 584, Alloy C83600 leaded red brass bearings; Neoprene rubber spider on enclosing tube.
      c. Enclosing tube: Steel pipe, ASTM A 53, Grade B unless scheduled otherwise.
   5. Lubrication system: Furnish complete oil lubrication system including solenoid shut off valve, oil reservoir, copper tubing, and everything needed for a complete working system.

C. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

D. Resonant Frequency: As specified in Sections 15050 and 15958.

E. Sleeves: Provide shafting with hardened sleeves where shafts pass through bearings or stuffing boxes; Brinell Hardness 550 or higher. When the specified mechanical seals cannot be installed on a hardened shaft sleeve, hardened shafts are not required in the area of the mechanical seal.
F. Design pump line shafting in interchangeable lengths as scheduled, but not to exceed 10 feet; shaft lengths to match scheduled pump column lengths. Shafting shall be polished over its full length.

G. Coupling Strength: Design driver to pump line shaft coupling of sufficient length and strength to maintain line shaft alignment.

H. Adjustment: Design a means to adjust shaft position to adjust impeller position. For motor driven units with solid shaft motors, design driver to pump line shaft coupling to allow adjustment of the impeller position.

I. Spacer Coupling: When mechanical seals are scheduled, provide an adjustable spacer coupling to allow removal of the seal without driver removal.

2.07 PUMP COLUMN PIPE

A. Pump Column Pipe: Thickness and material as scheduled.

B. Head Connection: Design with flanged and bolted connection to discharge head and flanged and bolted connection to impeller assembly to permit removal of impeller bowl assembly without disturbing the column or discharge connections.

C. Design Working Pressure: Design to withstand a design working pressure not less than 1.20 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.

D. Hydrostatically Pressure Test Discharge Head and Bowl Assembly: Design to withstand a 5 minute hydrostatic test pressure not less than 1.5 times the design working pressure; perform test at manufacturer's facility.

E. Lengths and Connections: Design with maximum 10 foot length, or less if scheduled, interchangeable column sections flanged connections.

F. Diameter: Design column inside diameter for no more than 2 feet of fluid friction loss per 100 feet of column length.

2.08 PUMP DISCHARGE HEAD ASSEMBLY

A. Design the discharge head for above or base discharge as scheduled.

B. Design the discharge vertical to horizontal flow transition as a smooth pipe elbow or from a minimum of 3 pipe pieces mitered to form the elbow.

C. Design discharge head to mate with the motor as scheduled.

D. Head and base plate construction shall be designed and as shown on plan to have sufficient strength, weight, and thickness to provide accurate alignment of all mating components, prevent excessive deflection and support the drive motor.

E. Stuffing Box and Seal:
1. Design the discharge head with a stuffing box to accommodate mechanical seals as scheduled.
2. Provide access to the stuffing box through windows placed 90 degrees from the discharge pipe centerline. Fit windows with removable expanded metal guards made from Type 304 stainless steel to protect the exposed shaft and coupling.
3. Mechanical Seal: Provide stuffing box suitable for the specified seal and provide solid shaft motor with spacer coupling.
4. Additional Seal Requirements: As specified in Section 15050.
5. Drain: Provide drain, minimum 3/4 inch size, for pump stuffing box leakage, together with drain line to the wet well through the discharge head.

F. Discharge Vent: Provide 3/4 inch NPT threaded high point vent on discharge; install pipe nipple with 3/4-inch threaded globe valves in vent.

G. Materials: As scheduled; when not scheduled, provide
   1. Pump Discharge Head/Driver Stand: Steel, ASTM A 283, Grade B or ASTM A 53, Grade B, or ASTM A 36.
   3. Stuffing Box and Seal: Container and gland, Cast Iron, ASTM A 48, Class 30 minimum; Neoprene top shaft seal.

2.09 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050.

2.10 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied. Increase driver horsepower, if required, to prevent driver overload while operating at any point of the supplied pump operating head-flow curve, including runout. However, electrical equipment will be sized for scheduled horsepower.

B. Motors: Provide premium high efficiency motors with characteristics as scheduled and meeting the requirements of Section 16222. When variable frequency drives (VFD) are scheduled, provide inverter duty motors suitable for operation with VFDs.
   1. Provide a vibration detector switch mechanically attached to the motor at or near the motor's upper bearing. The switch shall be tested at the vibration trip point specified by the manufacturer but shall not exceed the limits specified in Section 15958.
   2. Provide vibration switches by the following manufacturers, or equal:
      a. PMC/Beta, Model 440SR.
      b. Rochester Instrument Systems, Model VT-1215.
      c. VFD: Provide as scheduled meeting Section 16264.
   3. Provide temperature switches for motor upper bearing.
   4. Coordinate motors with VFD manufacturer to ensure compatibility between the motor and VFD.

C. Provide RTD per specification section 17604.
2.11 CONTROL SYSTEM

A. Pumps will be controlled remotely via variable speed drives as described in Section 17101.

2.12 SUPPORTS

A. Strength: Design pump discharge head, driver, and all connected components supports to withstand a minimum of 1.5 times the maximum imposed operating loads or the imposed seismic loads, whichever is greater.

B. Resonant Frequency: Design supports in conjunction with the pump, shafting, drivers, bearings and other components to avoid natural resonant frequencies, either torsional, radial or axial as specified in Section 15958.

C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.

2.13 FINISHES

A. Prepare surfaces and apply protective coatings as specified in Section 09960.

2.14 SOURCE QUALITY CONTROL

A. Witnessing: Source or factory testing shall be witnessed by the ENGINEER or OWNER; provide 30 day advanced notice of source testing as specified in Section 15958.
   1. Manufacture shall pay for airline travel and 5 days of lodging and food expenses during witness testing for one person.
   2. Travel shall be from San Francisco California to the factory location.

B. Equipment Performance Test: Test Level as scheduled; test as specified in accordance with Section 15958.

C. Vibration Test: Test Level as scheduled; test as specified in accordance with Section 15958.

D. Noise Test: Test Level as scheduled; test as specified in accordance with Section 15958.

E. VFD and Motor Factory Tests: Test as specified in scheduled section.

F. Hydrostatic Pressure Tests: As specified for components in this Section.

G. Balancing: Statically and dynamically balance all rotating components as specified in Section 15958.
PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as specified in Section 15050.

3.02 FIELD QUALITY CONTROL

A. Witnessing: All field-testing shall be witnessed by the ENGINEER; provide 30 day advanced notice of field testing as specified in Section 15958.

B. Inspection and Checkout: As specified in Sections 15050 and 15958.

C. Equipment Performance Test: Test Level as scheduled; test as specified in accordance with Section 15958.

D. Vibration Test: Test Level as scheduled; test as specified in accordance with Section 15958.

E. Noise Test: Test Level as scheduled; test as specified in accordance with Section 15958.

F. Motor Factory Tests: Test as specified in scheduled section.

G. Operational Testing: As specified in Section 01756.

3.03 MANUFACTURER'S FIELD SERVICES

A. Require manufacturer to inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and in Sections 15050 and 15958.

B. Training: As specified in Section 01756.

3.04 PUMP SCHEDULE

A. Pump OPS-PUM 400 shall be installed at a current rated design point of 33 feet and 5100 gpm. The pump shall be designed to be modified to a future design point of 87 feet and 5100 gpm. Refer to the pump schedule below for all current and future performance conditions.

1. Pump OPS-PUM 400 shall be installed with a VFD drive rated for 150 HP power per specification 16264. CONTRACTOR shall provide a 150 HP VFD drive that is fully compatible with a 75 HP motor and the future pump performance requirements.

2. Pump OPS-PUM 400 shall be installed with a 75 hp motor as specified.

B. The CONTRACTOR shall deliver OPS-PUM 400 bowl/impeller assemblies required for future flows identified in the schedule.

1. The bowl/impeller assembly required to meet the future performance conditions must be fully compatible with the shaft, column, and other appurtenances of the pump required to meet the current performance conditions. The future addition of a stage shall require no modification to the existing pump. The column and line shaft shall be designed for “bolt-in” replacement of the additional stage.
2. Pump must be supplied with proper spacers or a spool piece that is dimensionally interchangeable with the future addition of a stage.
3. The discharge head, motor shaft coupling, and head shaft shall be designed to allow “drop-in” replacement of the future 150 HP motor.
4. The bowl/impeller assembly for the future flow conditions shall be a ‘drop-in assembly’ that will required

C. The pump shall be delivered with the 75 hp (705 RPM) motor as specified. The submittal shall indicate the required motor specification for the future 150 hp (880 RPM) motor.

D. The below schedule below provides the performance conditions for OPS-PUM-400 current and future conditions.

A. Pump OPS-PUM 400 shall have a rated design point of 33 feet and 5100 gpm. The pump shall be designed so that it can be modified in the future to accommodate a design point of 87 feet and 5100 gpm. Refer to the pump schedule below for all current and future performance conditions.
   1. Pump OPS-PUM-400 shall be installed with a VFD drive rated for 150 HP power per specification 16264. CONTRACTOR shall provide a 150 HP VFD drive that is fully compatible with a 60 HP motor and the future pump performance requirements.
   2. Pump OPS-PUM-400 shall be installed with a 60 hp motor as specified.

B. The CONTRACTOR shall furnish a bowl/impeller assembly for OPS-PUM-400 for the future design point identified in the schedule.
   1. The bowl/impeller assembly required to meet the future performance conditions must be fully compatible with the shaft, column, and other appurtenances of the pump required to meet the current performance conditions. The future addition of a stage shall require no modification to the existing pump. The column and line shaft shall be designed for “bolt-in” replacement of the additional stage.
   2. Pump must be supplied with proper spacers or a spool piece that is dimensionally interchangeable with the future addition of a stage.
   3. The discharge head, motor shaft coupling, and head shaft shall be designed to allow “drop-in” replacement of the future 150 HP motor.

C. The pump shall be furnished with the 60 hp (705 RPM) motor as specified. The submittal shall indicate the required motor specification for the future 150 hp (880 RPM) motor.

D. The schedule below provides the performance conditions for OPS-PUM-400.

<table>
<thead>
<tr>
<th>Tag Numbers</th>
<th>OPS-PUM-100</th>
<th>OPS-PUM-200</th>
<th>OPS-PUM-300</th>
<th>OPS-PUM-400</th>
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<td>Service</td>
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<td>Tertiary Effluent</td>
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<td>Maximum Noise, dBA at 3 feet</td>
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<td>85</td>
<td></td>
<td></td>
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<tr>
<td>Torsion Analysis and Critical Speed Analysis</td>
<td>Required</td>
<td>Required</td>
<td>(Required for both future and current flow capacities)</td>
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<td>Minimum Pumped Fluid Degrees Fahrenheit</td>
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<td>22 to 130</td>
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**Pump Characteristics:**

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<th>Number of Stages</th>
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<td>Impeller Type</td>
<td>Enclosed Radial Flow</td>
<td>Enclosed Radial Flow</td>
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<tr>
<td>Pass Minimum Sphere Size, Inch</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Minimum Number of Impeller Vanes</td>
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<td>5</td>
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<td>Pump Impeller Bowl Bearing Lubrication</td>
<td>Oil Lubricated</td>
<td>Oil Lubricated</td>
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<td>Grease Lubricated</td>
<td>Grease Lubricated</td>
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</tr>
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<td>Suction Strainer</td>
<td>Required</td>
<td>Required</td>
<td></td>
</tr>
<tr>
<td>Anti-Vortex Baffle</td>
<td>Required</td>
<td>Required</td>
<td></td>
</tr>
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<td>Closed</td>
<td></td>
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<tr>
<td>Line Shaft Lubrication</td>
<td>Oil (drip feed)</td>
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</tr>
<tr>
<td>Tag Numbers</td>
<td>OPS-PUM-100</td>
<td>OPS-PUM-200</td>
<td>OPS-PUM-300</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
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<td>Discharge Shaft Seal Type</td>
<td>Tension Nut</td>
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<td>Column Connection Type</td>
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</tr>
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<td>Maximum Column Section Lengths, Feet</td>
<td>10</td>
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<td>Discharge Arrangement</td>
<td>Above Base</td>
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<td>Coupling Type</td>
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</tr>
<tr>
<td>Speed Control</td>
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<tr>
<td>Pump, rpm</td>
<td>880</td>
<td>705</td>
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<td>Rated Design Point (at Maximum rpm):</td>
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<td></td>
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<tr>
<td>Flow, gpm</td>
<td>5,100</td>
<td>5,100</td>
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<tr>
<td>Head, Feet</td>
<td>87</td>
<td>33</td>
<td>(Expandable to Future Head Condition of 87 feet)</td>
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<tr>
<td>Minimum Bowl Pump Efficiency, Percent</td>
<td>84 82</td>
<td>85 82</td>
<td></td>
</tr>
<tr>
<td>Required Condition 2 (at Maximum rpm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow, gpm</td>
<td>6,500</td>
<td>6,750</td>
<td></td>
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<tr>
<td>Head Range, Feet</td>
<td>49 to 51</td>
<td>16 -18</td>
<td>(Expandable to Future Head Condition of 48 to 51 feet)</td>
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<tr>
<td>Minimum Bowl Pump Efficiency, Percent</td>
<td>70 64</td>
<td>64</td>
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<tr>
<td>Required Condition 3 (at Maximum rpm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow, gpm</td>
<td>7,000</td>
<td>6,700</td>
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<tr>
<td>Head Range, Feet</td>
<td>30</td>
<td>18</td>
<td>(Expandable to Future Head Condition of 30 feet)</td>
</tr>
<tr>
<td>Minimum Bowl Pump Efficiency, Percent</td>
<td>66 62</td>
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<td></td>
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<tr>
<td>Required Condition 4 (at Maximum rpm):</td>
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<tr>
<td>Tag Numbers</td>
<td>OPS-PUM-100</td>
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<td>OPS-PUM-300</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Flow, gpm</td>
<td>3,750</td>
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<tr>
<td>Head Range, Feet</td>
<td>103 – 106</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>Minimum Bowl Pump Efficiency, Percent</td>
<td>60</td>
<td></td>
<td></td>
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<tr>
<td>Other Conditions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum NPSHr at every Specified Flow, Feet</td>
<td>25</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<tr>
<td>Minimum Water Level (from bottom of wet well), Feet</td>
<td>5.8</td>
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<td></td>
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<tr>
<td>Design Water Level (from bottom of wet well), Feet</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet Well Depth (From top of foundation for discharge head to bottom of wet well at pump centerline), Feet</td>
<td>21.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge Pipe Connection, inches</td>
<td>18</td>
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<td>Pump Materials:</td>
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<td>Suction Bell</td>
<td>Cast Iron</td>
<td></td>
<td>Cast Iron</td>
</tr>
<tr>
<td>Suction Bell Bearing</td>
<td>High Lead Tin Bronze</td>
<td>High Lead Tin Bronze</td>
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</tr>
<tr>
<td>Impeller Bowls</td>
<td>Cast Iron</td>
<td></td>
<td>Cast Iron</td>
</tr>
<tr>
<td>Impeller</td>
<td>Tin Bronze</td>
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<td>Tin Bronze</td>
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<tr>
<td>Tag Numbers</td>
<td>OPS-PUM-100</td>
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<td>---------------------------------</td>
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<td>Impeller Bearing</td>
<td>High Lead Tin Bronze</td>
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<tr>
<td>Impeller Bowl Shaft</td>
<td>416 Stainless Steel</td>
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<tr>
<td>Impeller Shaft Key</td>
<td>416 Stainless Steel</td>
<td></td>
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<td>Line Shaft and Coupling</td>
<td>416 Stainless Steel, with Stainless Steel Fasteners</td>
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<td>Line Shaft Bearings</td>
<td>Bronze</td>
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<td>Shaft Enclosing Tube</td>
<td>Steel</td>
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<tr>
<td>Shaft Sleeve</td>
<td>304 Stainless Steel</td>
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<td>Column Material and Thickness, Inch or Schedule</td>
<td>Steel Pipe, Minimum 0.375 inches</td>
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<td>Discharge Head/Driver Stand</td>
<td>Steel</td>
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<td>Discharge Head Bearing</td>
<td>High Lead Tin Bronze</td>
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<tr>
<td>Discharge Stuffing Box</td>
<td>Cast Iron</td>
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</tr>
<tr>
<td><strong>Driver Characteristics:</strong></td>
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<td>Driver Type</td>
<td>Motor</td>
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<tr>
<td>Variable Speed Drive Section</td>
<td>16264</td>
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<td>Vertical, Coupled</td>
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<td>Non-Reverse Ratchets</td>
<td>REQUIRED</td>
<td>REQUIRED</td>
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<tr>
<td>Rated Driver, Horsepower (No lower HP will be acceptable)</td>
<td>150</td>
<td>75-60</td>
<td></td>
</tr>
<tr>
<td>Maximum Driver Speed, rpm)</td>
<td>880</td>
<td>705</td>
<td>(880 future conditions)</td>
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<tr>
<td>Minimum Driver Speed Percentage (% of Maximum Driver Speed)</td>
<td>40</td>
<td>55</td>
<td></td>
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<td>Motor Characteristics (when motor is driver type):</td>
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<td>Motor Specification Section</td>
<td>16222</td>
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<td>Service Factor</td>
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<td>1.0</td>
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<td>Voltage/Phases/Hertz</td>
<td>460/3/60</td>
<td>460/3/60</td>
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<td>Source Quality Control Testing:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Test Witnessing</td>
<td>Witnessed</td>
<td>Witnessed</td>
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</tr>
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<td>Performance Test Level</td>
<td>2</td>
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</tr>
<tr>
<td>Vibration Test Level</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Noise Test Level</td>
<td>2</td>
<td>2</td>
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<td>Field Quality Control Testing:</td>
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</tr>
<tr>
<td>Performance Test Level</td>
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<tr>
<td>Tag Numbers</td>
<td>OPS-PUM-100</td>
<td>OPS-PUM-200</td>
<td>OPS-PUM-300</td>
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</tr>
<tr>
<td>Vibration Test Level</td>
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<td></td>
</tr>
<tr>
<td>Noise Test Level</td>
<td>2</td>
<td></td>
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</tr>
</tbody>
</table>

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The following safety equipment:
   1. Fire blanket.
   2. First aid kit.
   4. Life preserver.

1.02 REFERENCES

A. American National Standards Institute (ANSI):

B. Federal Specifications (FS):
   1. CS-191-53 (Fire retardant blanket).

C. NIOSH Schedule 13F.


1.03 SUBMITTALS

A. Shop Drawings.

B. Product Data:
   1. Submit manufacturer's product literature information for products specified.
   2. Manufacturer's Installation Instructions.

C. Samples.

D. Operation and Maintenance Data.

E. Operating and Maintenance Information for Safety Detectors: 6 complete sets.

F. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.

B. Installer Qualifications: Installer shall have 3 years experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.
C. Regulatory Requirements:
   1. As applicable, equipment of this Section shall comply with requirements of OSHA, Cal-OSHA, Underwriters Laboratories, NFPA, ASME, and U.S. Coast Guard.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and Protection: Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

D. Keep materials dry until ready for use. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.

E. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 FIRE BLANKET

A. Manufacturers: One of the following or equal:

B. Features/Characteristics:
   1. Blanket: Roller-type, fireproofed, nominal 62 by 84 inches.
   2. Case: Wall-mounted metal with friction-held door, no latch.

2.02 FIRST AID KIT

A. Manufacturers: One of the following or equal:
   1. VWR Scientific, 56613-048.

B. Features/Characteristics:
   1. Prefinished, wall-mounted metal cabinet.
   2. Standard medical supplies capable of serving up to 10 people.
   3. Meets OSHA requirements.

2.03 SAFETY ROPE

A. Manufacturers: One of the following or equal:
   2. California Safety.

B. Characteristics:
   1. Diameter: 9/16 inch.
   2. Length: 50 feet.
   3. Accessories: Snap hook on one end.
2.04 LIFE PRESERVER

A. Type: Doughnut-shaped, 30 inches diameter, with mounting brackets; U.S. Coast Guard approved.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install first aid kit and safety blanket in all three rooms.

B. Install safety rope and life preserver at top of cascade aeration structure.

C. Install products in accordance with manufacturers' recommendations.

D. Post safety precautions sign on wall adjacent to breathing apparatus masks.

E. Install fixed equipment in accordance with manufacturer's instructions.

F. Coordinate delivery and installation of equipment with laboratory casework.

G. Electrical connections and distribution shall be in accordance with Section 16050.

3.02 PROTECTION

A. Repair or replace defective equipment with new.

END OF SECTION
SECTION 13112

PIPELINE CORROSION MONITORING FACILITIES

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes: Pipeline corrosion monitoring facilities, including pipe joint bonding, pipe flange insulation, corrosion monitoring test stations, and associated equipment, materials, and miscellaneous items.

B. All joints along the 36 FE line are to be bonded and corrosion monitoring test stations shall be provided where shown on the drawings.

1.02  REFERENCES

A. American National Standards Institute (ANSI):

B. ASTM International (ASTM):
   1. B 3 - Soft or Annealed Copper Wire.

C. National Association of Corrosion Engineers (NACE):
   1. NACE RP 01 69 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
   2. NACE RP 02 86 - Standard Recommended Practices, the Electrical Isolation of Cathodically Protected Pipelines.

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment.

E. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code.

F. Underwriters' Laboratories (UL):
   1. UL 83 - Thermoplastic-Insulated Wires and Cables.
   2. UL 467 - Grounding and Bonding Equipment.
   3. UL 486A - Wire Connectors and Soldering Lugs for Use With Copper Conductors.
   4. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03  DEFINITIONS

A. Ferrous Metal Pipe: Any pipe made of steel or iron as well as containing steel or iron as a principal structural material.

B. Foreign-Owned Structure: Any buried pipe or cable not specifically installed under this contract.
C. Lead, Lead Wire, Joint Bonds, Cable, Conductor, Insulated Copper Conductor: The same as wire.

D. Electrically Continuous Pipeline: A pipeline which has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

E. Electrical Isolation: The condition of being electrically isolated from other metallic structures including, but not limited to, pipe, reinforcement, and casing, and the environment as defined in NACE RP 01 69.

1.04 SUBMITTALS

A. Submittals Prior to Starting Construction:
   1. 3 sets of catalog data for the manufactured items of materials, equipment, components, and test equipment to be used in the work described in this Section and indicated on the Drawings. Include specific performance data, material descriptions, ratings, capacities, brand names, catalog or part numbers, general or specific types, and all other pertinent information and data.
   2. Include the following items:
      a. Factory installed pipe joint bonding equipment.
      b. Pipe joint bonding cables.
      c. Test station boxes and terminal boards.
      d. Test station cables.
      e. Exothermic welding equipment.
      f. Exothermic weld caps.
      g. Coal tar mastic coating.
      h. Zinc reference electrodes.
      i. Pipe flange insulation materials.
      j. Testing instruments and equipment.
      k. Testing plans and schedule.
      l. Test records.
      m. Qualifications of Independent Corrosion Testing Firm.
   3. Ensure that items furnished fit the space available. Make necessary field measurements, including those for connections, and order such sizes and shapes of equipment in order that the final installation suits the true intent and meaning of the drawings and specifications.
   4. Where equipment requires different arrangement of connections from those indicated on the Drawings, install the equipment to operate properly and in accordance with the intent of the Drawings and specifications. Make all changes in the Work required by the different arrangement of connections.

B. Contact Closeout Submittals:
   1. Upon acceptance of the submittals, furnish 3 final copies of catalog data of materials, equipment, and components together with operating and maintenance instructions.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: All materials, workmanship, and installation shall conform with all requirements of the legally constituted authorities having jurisdiction. These authorities include, but are not limited to:
3. All other applicable Laws and Regulations.

B. Nothing in the Drawings or this Section is to be construed to permit work not conforming to the above-referenced regulations and codes.
   1. Where larger size or better grade materials than required by these regulations and codes are specified, the Drawings and this Section shall have precedence.
   2. Obtain any required permits and inspections.

C. After construction inspection, continuity testing, and baseline potential measurements shall be performed by an independent testing firm regularly engaged in corrosion protection systems and corrosion monitoring for a period of not less than 10 consecutive years; and can show evidence of this experience on at least 5 similar projects of similar size and scope.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store all materials and equipment in such a manner as to protect from the detrimental effects of the elements.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe Joint Bonding Cables:
   1. Number 2 American Wire Gauge (AWG) stranded copper, single conductor, with high molecular weight polyethylene insulation designed for direct burial and cathodic protection use.
   2. Provide sufficient length for minimum slack of 2 feet to avoid stress during the backfilling of the pipe, and in the event of pipe deflection and/or movement.
   3. Equip cables with a tinned copper crimp-type ring terminal on each end for connection to the threaded bosses on the bell and spigot ends of the pipe sections.
      a. Terminal: Manufacturers: One of the following or equal:
         1) Thomas & Betts Corporation, Edison, New Jersey, STA-KON #G2-12.
   4. Connect the pipe joint bonding cables to the threaded bosses using monel alloy hex head national course threaded bolts, 1/2 inch diameter by 2 inches long each, and monel alloy flat washers.

B. Corrosion Monitoring Test Stations:
   1. Flush Mount Type Test Stations: Each test station shall include the following:
      a. Housing Boxes: 14 by 14 by 12 inches deep "PC" service box, open base type, complete with heavy duty steel or cast iron traffic cover.
         1) Imprint top of cover shall be "CORROSION TEST STATION."
         2) Manufacturers: One of the following or equal:
            a) Quazite Composolite Company, Lenoir City, Tennessee, Model No. PC1212BG12.
            b)
b. Test Boxes: Cast aluminum suitable for mounting on 2 inch diameter rigid polyvinyl chloride conduit.
   1) Manufacturers: One of the following or equal:
   2) Cover: Cast aluminum with locking mechanism.
   3) Terminal Block: 8 terminal type of glass reinforced laminated plastic mounted inside test box, with nickel plated brass terminal studs (non-turning), nuts, lockwashers, and shorting straps.

c. Polyvinyl Chloride Conduit: Schedule 80, 2 inches diameter by 36 inches long.

2. Post mount type test stations.
   a. Test Boxes: Cast aluminum, suitable for mounting on 2 inch diameter rigid galvanized steel conduit.
      1) Manufacturers: One of the following or equal:
      2) Cover: Cast aluminum with locking mechanism.
      3) Terminal Block: 8 terminal type of glass reinforced laminated plastic mounted inside test box, with nickel plated brass terminal studs (non-turning), nuts, lockwashers, and shorting straps.
   b. Wood Post: Pressure treated cedar or redwood, 4 inches by 4 inches by 72 inches long.
   c. Conduit and Fittings:
      1) Conduit: Rigid galvanized steel, 2 inch diameter.
      2) Conduit Straps: Galvanized steel, two hole type, for 2 inch galvanized steel conduit.
      3) Conduit Bushings: Plastic type, for use on 2 inch diameter galvanized steel conduit.

C. Test Station Cables:
   1. Number 10 AWG stranded copper, single conductor, with XHHW insulation of the color as indicated below.
      a. Test station cable insulation shall indicate the source or type of pipeline or structure each represents when terminated inside the test stations, as follows:
         1) WHITE - Pipeline being constructed under this contract.
         2) BLUE - Water line.
         3) GREEN - Sewer line.
         4) YELLOW - Gas line.
         5) RED - Casing.
      b. The test cable color shall be impregnated in the insulation material. Colored tape or paint will not be acceptable.
      c. Where 2 sets of test cables of the same color from two pipelines of the same type are terminated in the same test station, identify one set or distinguish from the other set by means of the installation of heat shrink sleeves on the cables.
         1) The heat shrink sleeves shall be 12 inches long each placed on the cables a minimum of every 8 feet from the pipeline to the test station.
         2) The color of the heat shrink sleeves used for this purpose shall be black.
d. In addition to the heat shrink sleeve identification, where two sets of the same color test cables are terminated in the same test station, label both sets of cables inside the test station to distinguish one set from the other.

D. Test Station Cable Terminals:
1. For connecting corrosion monitoring test station cables to the pipeline being constructed under this contract install crimp-type ring terminals (1/2 inch diameter, tinned copper) on the ends of the cables.
   a. Terminals for Number 10 AWG Cable:
      1) Manufacturers: One of the following or equal:
         a) Thomas & Betts Corporation, Edison, New Jersey, STA-KON No. 10-12.
2. For terminating the cables inside the corrosion monitoring test stations, use crimp-type ring terminals which are 1/4 inch diameter, tinned copper.
   a. Terminals for Number 10 AWG Cable:
      1) Manufacturers: One of the following or equal:

E. Exothermic (Thermite) Weld Equipment:
1. General:
   a. Use exothermic (thermite) welding to attach corrosion monitoring test station cables to existing metallic pipelines crossed by the pipeline being constructed under this contract using exothermic (thermite) welding.
   b. Equipment and Weld Material:
      1) Manufacturers: One of the following or equal:
         a) ERICO Products, Inc. (CADWELD), Cleveland, Ohio.
      c. Interchanging of thermite weld materials from different manufacturers will not be allowed.
   d. The welder size and type, the weld metal charge size and type, and the associated items used shall be as determined and recommended by the manufacturer in accordance with the following parameter:
      1) Pipe material (i.e., steel, cast iron, ductile iron.
      2) Pipe size (diameter) and wall thickness.
      3) Cable size.
      4) Orientation of weld connection.
2. Equipment:
   a. Molds: Molds must be constructed of graphite. Ceramic "one-shot" molds will not be acceptable.
   b. Adaptor Sleeves: Provide sleeves for Number 10 AWG cable, and Number 2 AWG joint bond cables. Prefabricated factory sleeved joint bonds or bond cables with formed sleeves made in the field are acceptable. Attach field-formed joint bond sleeves with the appropriate size and type of hammer die provided by the thermite weld manufacturer.
   c. Cartridges: Use cast iron thermite weld cartridges for all cast and ductile iron pipes and fittings. Maximum cartridge size: 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.

F. Thermite Weld Caps: Weld caps used to cover finished exothermic weld connections of test cables to pipes:
1. Install weld caps using the appropriate primer in strict accordance with the manufacturer's recommendations.
2. Manufacturers: One of the following or equal:

G. Coal Tar Mastic Coating:
   1. Manufacturers: One of the following or equal:

H. Zinc Reference Electrodes:
   1. 4 by 1.4 by 9 inches long, cast of high purity zinc in accordance with ASTM B 6.
   2. Supply the zinc reference electrodes packaged in permeable cloth bags containing the following:
      a. 50 percent bentonite.
      b. 50 percent gypsum.
   3. Supply each zinc reference electrode with a 100 foot long lead wire of Number 10 AWG stranded copper, single conductor, with yellow XHHW insulation.
   4. Connect the lead wire to the steel core of the zinc reference electrode by silver soldering. Epoxy encapsulate or tape wrap the connection to ensure waterproofing. Provide connection stronger than the Number 10 AWG cable being used.

I. Pipe Flange Insulation Materials:
   1. Manufacturers: One of the following or equal:
   2. Flange Gasket: Type "E" full flange face type, constructed of neoprene faced phenolic, of proper size and ANSI pressure rating as required.
   3. Insulating Sleeves: Mylar, 1/32 inch thick, of proper size to fit flange bolts; one sleeve required for each bolt.
   4. Insulating Washers: G3 glass phenolic, 1/8 inch thick, of proper size to fit flange bolts. 2 washers are required for each bolt.
      a. For insulated pipe flanges that will be buried, use stainless steel bolts and nuts instead of standard carbon steel parts.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Furnish and install all materials and equipment associated with pipe joint bonding, corrosion monitoring stations, and insulated flanges as indicated on the Drawings and described in this Section.
      a. Install all items as specified and indicated on the Drawings. Any changes in the design or method of installation of an item as specified and indicated on the Drawings must be accepted prior to installation.
      b. Coordinate the installation of the various components to coincide with other construction phases of the Project so that installation of the items herein specified can be completed in the most efficient and expedient manner.

B. Special Techniques:
   1. General:
a. In order to form an electrically continuous pipeline facility in the areas required, bond buried and above ground pipe joints as specified.  
1) Included in the specified electrically continuous pipeline sections, bond all vault and manhole piping and fittings as necessary.  
2) Pipe joints that are to be field welded for restraining purposes, as specified, will not require bonding.
b. Each bonded pipe joint shall be tested as specified under paragraph “Testing During Construction”.

2. Ductile Iron Pipe:  
a. Bond all ductile iron pipe joints, except as indicated on the Drawings and as specified in this Section, to provide complete electrical continuity along the pipeline system.  
b. Install 2 bonding cables across each pipe joint using the exothermic welding process in accordance with the manufacturer’s instructions and recommendations, and as specified elsewhere in this Section.  
c. Bond pipe couplings and expansion fittings in strict accordance with the details indicated on the Drawings, ensuring that rings, spools, center pieces, and other associated parts are connected.  
d. Bonding cable connections on the ductile iron pipe joints and associated fittings shall be inspected by the ENGINEER before the application of coating and the backfilling of the pipe.  
1) Coat the bonding cable connections using thermite weld caps and coal tar mastic as indicated on the Drawings and specified elsewhere in this Section.

C. Corrosion Monitoring Test Stations:  
1. General:  
a. Install corrosion monitoring test stations along the pipeline system at the locations specified in TABLE NO. 1, TEST STATION LOCATION, TYPE, AND CABLE INFORMATION, included under Article “Schedules” at the end of this Section.  
b. Install corrosion monitoring test stations along the pipeline system as shown in the Drawings.  
1) Table Number 1 indicates the general locations of the test stations. In conjunction with the ENGINEER, determine the exact location of each test station based on actual site conditions and other circumstances that may be involved.  
1) Position each test station off the streets and in protected, accessible locations, as accepted by the ENGINEER.  
2) Connect test station cables to the various pipeline structures in accordance with the Drawings and this Section.  
3) Connect test station cables inside the test boxes using crimp-type ring terminals of the size required and the type specified herein.  
4) Place underground cable runs installed less than 24 inches below the finish grade in conduit.

2. Flush Mount Test Stations:  
a. Install the flush mount test stations at the locations indicated in Table Number 1 at the end of this Section, and as indicated on the Drawings.  
b. Install the flush mount test stations, per the typical details, at the locations shown in the Drawings.  
b. Install the 14 inch by 14 inch by 12 inch service boxes even with the finish grade, and bed in pea gravel.
1) The pea gravel shall be a minimum of 6 inches deep.
2) The pea gravel inside the service box shall be no higher than 2 inches above the bottom of the box.
   c. The 2 inch diameter polyvinyl chloride conduit installed inside the box shall extend no more than 3 inches above the bottom of the box.
   1) The top of the polyvinyl chloride conduit shall be trimmed smooth and flat.
   d. The test station terminal box or boxes (as required), complete with terminal boards, hardware, and cover(s), shall be laid inside the service boxes, but shall not be installed on the polyvinyl chloride conduit.
   e. The test cables terminated inside the test station terminal boxes shall each have a sufficient coil of slack cable to allow the test station terminal boxes to be lifted out of the service boxes for a minimum distance of 18 inches.
3. Post Mount Test Stations:
   a. Install post mount test stations as specified in TABLE NO. 1, TEST STATION LOCATION, TYPE, AND CABLE INFORMATION and as indicated on the Drawings.
   b. Mount the test box on the wood post with 2 inch diameter galvanized steel conduit attached to the wood post using galvanized steel conduit straps and galvanized steel nails or screws.
   c. Install a plastic conduit bushing on the underground end of the conduit to prevent damage from occurring to the insulation on the test cables when being pulled through the conduit.
      1) A minimum slack loop of 12 inches shall be left in each test cable at the bottom of each test station conduit to prevent stretching and possible damage to the cables during the backfilling around the test station.
   d. Cut top of each wood post at a 45 degree angle away from the test box to provide run-off of rain and moisture away from the test box. Coat the 45 degree cut with two layers of coal tar mastic to prevent saturation of the wood post by rain and moisture.
      1) Coat the bottom and all four sides of each wood post with a layer of coal tar mastic for a distance of about 30 inches up from the bottom to provide 6 inches of coating above the top of the concrete pads.
      2) Allow the coating to dry for at least 24 hours before the posts are set in the concrete pads.
   e. The 18 inch by 18 inch by 12 inch deep concrete pad in which each assembled test station shall be set and reinforced with Number 4 reinforcing bars tied together as indicated on the Drawings, with 4 inches of concrete cover over the bars on top, bottom, and all four sides.
      1) Slope the top of each concrete pad away from the center to the 4 sides to provide run-off of rain and moisture, and to prevent puddling of water around the base of the test station post.

D. Exothermic Welding Procedures:
   1. The connection of copper cables, including bonding cables and test station cables, to steel and ductile iron surfaces shall be made by the exothermic (thermite) weld method.
      a. Observe proper safety precautions, welding procedures, exothermic weld material selection, and surface preparation as recommended by the welding equipment manufacturer.
b. Assure that the pipe or fitting wall thickness is of sufficient thickness that the exothermic weld process will not damage the integrity of the pipe or fitting wall or protective lining.

2. Before each connection is made, clean the surface to bare metal by making a minimum 2 inch by 2 inch window in any previously applied pipeline coating, and then file or grind the surface to produce a bright metal finish.
   a. Accomplish grinding with a vitrified type grinding wheel. The use of a resin, rubber, or shellac impregnated type grinding wheels will not be acceptable.
   b. The prepared metal surface shall be dry.

3. Install copper sleeves on the ends of the cables before welding to the metal surface.
   a. Remove only sufficient insulation from the cables to allow the installation of the copper sleeves and proper placement in the welder mold.
   b. Perform thermite welding in strict accordance with the manufacturer's written instructions.
   c. After the weld connection has cooled, remove all slag by wire brushing, and physically test the cable connection by several sharp blows with a hammer. Remove and replace any defective connections.
   d. After the weld is completed, trim cable insulation smooth prior to coating. Clean welds and surrounding area free of slag and dirt prior to coating.
   e. The completed weld connections shall be inspected and accepted by the ENGINEER before final coating of the welds and backfilling of the pipe.

4. Following the cleaning and testing of each weld, install a prefabricated thermite weld cap over the weld connection area.
   a. Use the proper weld cap primer for the installation of the weld cap, in strict accordance with the manufacturer's specifications and recommendations.
   b. Following the installation of the thermite weld cap, coat the entire cable connection weld area with two coats of coal tar mastic, in accordance with the manufacturer's specifications and instructions.
      1) Allow sufficient time between the coating applications to provide proper curing of the coating.
      2) Apply sufficient coating to ensure that any exposed metal, including copper cable, is completely covered.

5. Completed pipe joint bonding connections and test station cable connections shall be inspected and accepted by the ENGINEER prior to the backfilling of the pipe.

E. Cable Splicing and Insulation Repair:
1. Cable splicing will not be allowed, except as accepted by the ENGINEER.
   a. Make acceptable cable splices using a suitable sized copper alloy compression connector as accepted by the ENGINEER, or by mechanically securing and solder with a 50/50 rosen cure solder.
      1) The completed splice shall be inspected and accepted by the ENGINEER, after which it shall be spiral wrapped with two layers of high voltage rubber insulating tape using a 50 percent overlap during the wrapping.
      2) Cover the rubber splicing tape wrap with two layers of a high quality vinyl electrical tape, also applied with a 50 percent overlap.

2. Any damage to cable insulation shall be inspected by the ENGINEER to determine whether repairs to the insulation can be made or the cable must be replaced.
a. If accepted by the ENGINEER, repairs to damaged cable insulation shall be made in the following manner:
   1) Thoroughly clean the cable in the area of the insulation damaged to remove all dirt, grease, and other materials.
   2) Wrap the cable with a minimum of two layers of high voltage rubber tape for a distance of at least 4 inches beyond the insulation damage area in both directions. The tape wrapping shall be made in a spiral manner using a minimum 50 percent overlap.
   3) Completely cover the high voltage rubber tape wrapping with a minimum of two layers of good quality vinyl electrical tape, for a distance of 4 inches beyond the high voltage rubber tape wrapping in both directions. Apply the vinyl electrical tape in a spiral manner using a minimum 50 percent overlap.

F. Zinc Reference Electrodes:
   1. Install the zinc reference electrodes at the location and in the manner as indicated on the Drawings.
      a. Place the reference electrodes at a maximum distance of 12 inches from the pipe.
      b. Do not handle the reference electrodes or lower by the cable.
      c. Remove plastic or paper bags used for protection during shipping from the reference electrode before installation.
      d. Place native soil free of rocks and clods around the reference electrode in 6 inch lifts and well compacted. When compacted soil has been placed on the top of the reference electrode, pour water into the hole to saturate the reference electrode, the backfill, and the surrounding soil.
      e. Continue backfilling with soil compacted in 6 inch lifts to the ground surface.
      f. Any damage caused to the reference electrode or its components will require replacement of the entire assembly.

G. Cable Installation:
   1. Install buried cables straight without kinks, and a minimum cover of 24 inches.
      a. Install test station cables with less than 24 inches of ground cover in rigid polyvinyl chloride conduit, as accepted by the ENGINEER.
      b. The bottom of the cable trench shall be free from stones, roots, or other materials which might damage the insulation of the cables.
      c. Install cables in conduit from the top of the pipe to the test boxes where backfill may damage the cables.
   2. Each cable shall be continuous in length and free of splices unless otherwise specified or accepted by the ENGINEER.
      a. Use care during installation to avoid abrasions, punctures, cuts, or any other damage to cable insulation.
      b. Repair or replace any damage to insulation.

H. Cable Warning Tape:
   1. All buried cables (except pipe joint bonding cables) shall have warning tape placed 10 inches to 12 inches above the entire lengths during the backfilling operations. Bring the warning tape to within 6 inches of the finish grade.

I. Pipe Flange Insulation:
1. Provide pipe flanges with electrical insulating materials (insulating flange kits) at the locations indicated on the Drawings to provide electrical isolation of specified sections of the pipeline from the other sections.
   a. Install all piping and piping components free of foreign materials and construction debris.
   b. The gasket seating surface shall be free from tool marks, scratches, pits, deposits, or gouges greater than the regular machining marks in a circular pattern (except of the specified surface finish typically 125-200 AARH). If the seating surface is damaged, machine within the tolerance of the flange specification. If remachining is not possible, replace the flange.

2. Install the insulating flange kit materials in strict accordance with the manufacturer's instructions and recommendations.
   a. Align pipe flanges for installation of bolts (studs) flange gasket, insulating sleeves and washers, and metallic washers and bolts.
   b. Use lubricant or anti-seizing compound, as recommended by the insulating flange kits, on bolt and nut threads to provide proper engagement and facing of parts.
   c. Install the bolts (studs) and associated parts finger-tighten in the sequence as outlined in the manufacturer's installation instructions.
   d. After the installation is completed, torque the studs in the proper sequence as directed by the manufacturer's installation instructions.

3. Following the completed installation of each insulating flange kit, conduct electrical resistance testing to ensure that all flange insulation components have been properly installed and that proper electrical insulation has been achieved.
   a. Measure the electrical resistance across each individual stud (bolt) in the flange, in accordance with NACE RP 02 86.
      1) Accomplish the testing in the presence of the ENGINEER, with the pipe empty and one side of the pipe flange undergrounded at the time of the testing.
      2) Accomplish the testing with a ohm-meter acceptable to the ENGINEER.
      3) The minimum acceptable resistance across each individual stud (bolt) shall be 50,000 ohms.
   b. Remove and replace any defective insulating parts with new parts.
      1) Following the removal and replacement of defective parts, repeat the resistance tests with all flange studs (bolts).

3.02 FIELD QUALITY CONTROL

A. Testing During Construction:
   1. Furnish all necessary equipment and materials and make all electrical connections to the pipe as required to test the electrical continuity of bonded pipe joints.
   2. Conduct a continuity test on each pipe joint that is required to be bonded. Test the electrical continuity of each pipe joint before bonding and after the bonds have been installed, but before backfilling of the pipe.
   3. Test Equipment Required:
      a. Furnish the Following Equipment and Materials:
         1) Digital low resistance ohmmeter: Manufacturers: One of the following or equal:
            a) Biddle, Model 247001.
2) One Set of Duplex Helical Current and Potential Hand Spikes: 
   Manufacturers: One of the following or equal:
   a) Biddle, Model Number 241001, cable length as required.
3) One calibration shunt rated at 0.001 ohms and 100 amperes.
   Manufacturers: One of the following or equal:
   a) Biddle, Model Number 249004.

b. Store the above-described equipment at the project site and maintain the equipment in good working condition. The equipment shall be available for use by the ENGINEER or the OWNER during the construction. Upon completion of the Project, turn the equipment over to the OWNER along with all manuals and associated items.

4. Test Procedure:
   a. Measure the resistance of each pipe joint before and after bonding, using the low resistance ohmmeter in accordance with the manufacturer's written instructions.
   b. Use the helical hand spikes to contact the pipe on each side of the joint. When taking measurements after the pipe joint bonding cables have been installed, do not touch the exothermic weld or the bonding cables.
   c. Clean the contact area to bright metal by filing or grinding, with all surface rusting or oxidation removed.
   d. Take measurements both forward and reversed to ensure no DC interference.
   e. Record the measured pipe joint resistances on a permanent record and submit three copies to the ENGINEER.
   f. Repair any damaged pipe coating in accordance with the specifications, using only compatible and accepted materials.

5. Joint Bond Acceptance:
   a. Resistances of bonded pipe joints shall be less than or equal to the maximum allowable bond resistance values shown as follows:

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Maximum Allowable Resistance (2 bond cables per joint)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push-on or Mechanical</td>
<td>0.000162 ohm</td>
</tr>
<tr>
<td>Flexible Coupling</td>
<td>0.000175 ohm</td>
</tr>
<tr>
<td>Joint Bond</td>
<td>0.000081 ohm</td>
</tr>
</tbody>
</table>

b. Replace any joint bonds which exceeds the allowable resistance. Retest replacement joint bonds for compliance with the specified bond resistance.

6. Test Records:
   a. Maintain a complete record of all resistance testing conducted at each pipe joint, before and after joint bonding cables have been installed.
   b. Submit the original and three copies of the test data to the ENGINEER for evaluation within 24 hours after the testing has been completed.
   c. The Test Records Shall Include:
      1) The location (pipeline station number), and a brief description of the joint type, fitting.
      2) The date of the test and the status of the joint (before or after bonding).
      3) The resistance measured.
4) Any comments.

d. Notify the ENGINEER at least 24 hours before pipe joint resistance testing is to be conducted, in order that the testing may be witnessed by the ENGINEER.

B. Testing after Construction:

1. The CONTRACTOR shall hire an independent test firm to perform inspection, continuity testing, and baseline potential measurements. Submit corrosion monitoring agency qualifications as specified herein for review and approval by the ENGINEER and OWNER.

2. Perform electrical continuity testing on the entire bonded pipeline system or specified bonded sections of the pipeline system installed as part of Project to ascertain and ensure that all pipe joint bonding has been properly installed and is functioning as designed.

   a. Complete the continuity testing after the pipe joint bonding and installation of the corrosion monitoring test stations have been completed.

   b. Purchase the following test equipment at least 60 days before the continuity testing is to begin, to ensure that it will be available for the testing:

      1) 1 Each Digital Multimeter with Case and Test Leads: Manufacturers:
          One of the following or equal:
          a) Beckham Instruments, San Diego, California, Model HD-100.

      2) 2 Each Copper/copper-sulfate Reference Electrodes: Manufacturers:
          One of the following or equal:
          a) Tinker & Rasor, Inc., San Gabriel, California, Model 8B.

      3) 1 pound Copper Sulfate Crystals: Manufacturers: One of the following or equal:
          a) Tinker & Rasor, Inc., San Gabriel, California.

      4) One Quart Copper Sulfate Anti-freeze Solution: Manufacturers: One of the following or equal:
          a) Tinker & Rasor, Inc., San Gabriel, California.

c. Store the equipment at the project site and maintain the equipment in good working condition. The equipment shall be available for use by ENGINEER or the OWNER. Turn the equipment over to the OWNER along with all manuals and associated items upon completion of the project.

3. At least 3 weeks before continuity testing is to be accomplished, submit a testing plan and schedule to the ENGINEER.

   a. This plan and schedule shall include a list of the equipment that will be used for the testing, including power supply, auxiliary (temporary) ground, reference electrodes, voltmeters.

4. Testing Procedure:

   a. Conduct the continuity tests by measuring the response of the potential of the piping to the application of a simulated cathodic protection test current in the following manner:

      1) Install an auxiliary (temporary) ground at a minimum distance of 10 feet from the pipeline near or adjacent to a corrosion monitoring test station.

      2) Connect the auxiliary ground to the positive DC output terminal of a portable cathodic protection rectifier unit or "steady source" DC power supply, as accepted by the ENGINEER.
3) Connect the negative DC output terminal of the rectifier or DC power supply to the pipeline by means of the test cables in the corrosion monitoring test station.

4) Adjust the DC output of the rectifier or power supply to provide a pipeline potential no more negative than minus 2.00 volts with respect to a standard copper/copper-sulfate (Cu/CuSO₄) reference electrode in contact with the earth directly over the pipeline at the test station location.

5) Record the DC voltage and current output of the rectifier or power supply, along with the pipeline-to-Cu/CuSO₄ potential measured at or near the auxiliary ground.

6) With the DC test current turned on and off on a cycling basis (by means of a current interrupter installed in the test circuit), "on" and "off" pipe-to-Cu/CuSO₄ potential measurements shall be taken at each corrosion monitoring test station in both directions away from the auxiliary ground and power source.

7) Pipe-to-Cu/CuSO₄ potential measurements of "foreign" lines and/or casings located at test stations shall also be taken with the simulated cathodic protection current "on" and "off."

8) All measurements shall be recorded.

b. When the pipe-to-Cu/CuSO₄ potential change from "off" to "on" becomes less than 300 millivolts, move the auxiliary ground and the power supply to a new location, with the testing procedure as described in Items a through g repeated until the entire bonded pipeline or bonded pipeline sections have been tested.

When the pipe-to-CU/CuSO₄ potential change from "off" to "on" becomes less than 300 millivolts, move the auxiliary ground and the power supply to a new location, and repeat the testing and repair procedures as described in Items 1 through 8 until the entire bonded pipeline or bonded pipeline sections have been tested.

1) Take all pipe-to-Cu/CuSO₄ potential measurements utilizing the Digital Multimeter and the copper/copper-sulfate reference electrodes to be purchased by the CONTRACTOR as part of the Project, and as specified earlier in this Section.

2) Accomplish all continuity testing in the presence of the ENGINEER.

c. Baseline potential measurements:

1) After backfilling of pipe and installation of electrodes and test stations are complete, static potential measurements of pipes shall be made.

2) Baseline potential measurements of pipe shall be made at each test station installed under this Contract:
   a) With respect to buried reference electrodes at each location.
   b) With respect to a portable copper-sulfate reference electrode in contact with earth directly over pipe at each test station.
   c) With respect to a portable copper-sulfate reference electrode over pipe on each side of each known pipeline crossing shown on the Drawings.

3) All baseline potential measurements shall be recorded and submitted to the ENGINEER, including values obtained, date, time, and location.
C. Inspection:

5. Upon completion of all work, the corrosion control facilities installed under this contract will be inspected and tested by the ENGINEER to assure complete conformance with the Contract Documents.

6. Any unapproved deviations or changes from the design made by the CONTRACTOR during the installation of these facilities shall be corrected.

7. Any or all deficiencies in the facilities found through the final testing shall be corrected to meet the requirements of the Contract Documents.

C. Inspection:

1. Upon completion of all work, the corrosion monitoring facilities installed under this Contract will be inspected and tested by an independent testing firm to assure complete conformance with the Contract Documents. Inspection shall include all lead cables, reference electrode cables, and corrosion monitoring station. Testing by the independent testing firm will include all continuity testing and baseline potential measurements and shall be completed after the pipeline is backfilled and the pipeline corrosion monitoring facilities are installed.

2. Any unapproved deviations or changes from the design made by the CONTRACTOR during the installation of these facilities shall be corrected.

3. Any or all deficiencies in the pipeline corrosion monitoring facilities found through inspection and testing shall be corrected by the CONTRACTOR to meet the requirements of the Contract Documents prior to acceptance by the ENGINEER and OWNER.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Prefabricated metal building systems.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01455 - Special Tests and Inspections.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 01614 - Wind Design Criteria.
      d. Section 01770 - Closeout Procedures.
      e. Section 03600 - Grouting.
      f. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

B. American Institute of Steel Construction (AISC):
   1. 360 - Specification for Structural Steel Buildings.

C. American Iron and Steel Institute (AISI):
   1. SG02 - North American Specification for the Design of Cold-Formed Steel Structural Members.

D. ASTM International (ASTM):
5. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
10. F 959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners
11. F 436 - Standard Specification for Hardened Steel Washers

E. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.3 - Structural Welding Code - Sheet Steel.

F. California Code of Regulations (CCR):
   1. Title 24 – Building Standards Code.

G. FM Global (FM).

H. International Accreditation Service (IAS):
   1. AC472 - Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems.

I. International Code Council (ICC):

J. Metal Building Manufacturing Association (MBMA):

K. Occupational Safety and Health Administration (OSHA):
   1. Occupational Safety and Health Standards:
      a. 1910.23 - Guarding floor and wall openings and holes.

L. Society for Protective Coatings (SSPC):
   1. SSPC-SP2 - Hand Tool Cleaning.

M. Steel Door Institute (SDI):
   1. A250.8 - Recommended Specifications for Standard Steel Doors and Frames.

N. Underwriters’ Laboratories, Inc. (UL):
1.03 DEFINITIONS

A. Primary framing: An assemblage of beams and columns that support the secondary framing members, and that collects loads to transfer to the building foundation.

B. Secondary framing: Members which directly support roof, wall, or floor surfaces and convey loads to the primary framing.

1.04 SYSTEM DESCRIPTION

A. System:
   1. Design: Furnish metal building with vertical walls, roof, and with column layout as indicated on the Drawings.
   2. Size:
      a. Furnish metal building of the size and configuration indicated on the Drawings.
      b. Coordinate manufacturer's design dimensions for metal building system components, including columns, with equipment foundations, and details indicated on the Drawings.
   4. Provide building with horizontal and vertical bracing where indicated on the Drawings.
   5. Column reactions shall be vertical and horizontal only.
      a. No bending moments shall be transferred at column bases.
   6. The building roofing system will be listed for a UL 580, Class 90 designation.
   7. Openings: Frame openings for doors, windows, louvers, equipment with structural framing to replace panels and secondary framing cut for opening.
      a. Provide curbs to suit roof-mounted equipment compatible with roof sheathing.

B. Performance requirements:
   1. General:
      a. Design of the metal building structure and its appurtenances shall conform to the requirements of the IBC, the Metal Building Systems Manual, and the requirements of this Section.
         1) Where the Metal Building Systems Manual conflicts with the requirements of this Section, the more restrictive requirements will govern.
      b. Do not include collateral or auxiliary loads in load combinations where dead loads offset other load effects (for example, uplift due to wind loads).
      c. Hot-rolled structural steel sections or welded-up plate sections: Design in accordance with AISC 360.
      d. Cold-formed steel structural members: Design in accordance with the AISI North American Specification for the Design of Cold-Formed Steel Structural Members.
      e. Anchor bolts:
         1) Design anchor bolts to resist column reactions reported from analysis.
         2) Design anchor bolts in accordance with ACI 318 Appendix D for cracked concrete to fail in a ductile manner, yielding the steel section before fracturing the surrounding concrete.
3) Assume concrete foundation strength, $f'c = 4,000$ pound per square inch at 28-days.

2. Loading:
   a. General:
      1) Design building for dead load, live loads, and combinations of loads including unbalanced loads in accordance with the IBC and the MBMA Metal Building Systems Manual, except as modified in this Section.
      2) Reduction in wind, live, or snow loads based on tributary loaded area will not be permitted.
   b. Roof loading requirements:
      1) Live load: Minimum 20 pounds per square foot assumed to act vertically on horizontal projected area of roof.
      2) Ground snow load: 0 pounds per square foot assumed to act vertically on horizontally projected area of roof.
      3) Rain on snow surcharge load: 0 pounds per square foot assumed to act vertically on horizontally projected area of roof.
   c. Collateral loading: Uniform roof load of 10 pounds per square foot assumed to act vertically on horizontal projected area of roof to account for miscellaneous accessories supported from the structure.
      1) Collateral loading shall be considered a live load and therefore considered concurrently with roof live load.
      2) Design primary and secondary framing to support the additional weight of mechanical equipment such as fans, air conditioners, etc. shown on plans.
         a) Mechanical equipment weights are in addition to collateral loading.
   d. Auxiliary loading:
      1) Structural members: Any single point along the secondary roof framing members shall be designed to carry a concentrated load of 200 pounds in addition to the roof live load.
      2) Roof panels: Design panels to support a 200 pound load uniformly distributed over a 2 square foot area centered between supporting framing members, without exceeding a panel deflection to span ratio of 1/180 in a 2-span condition.
      3) Auxiliary loading shall be considered a live load.
      4) Auxiliary is not to be considered concurrently with collateral loading.
   e. Wind loading requirements: As specified in Section 01614.
      1) Design roof purlins and structural frames for loads specified, but not less that 20 pounds per square foot uplift on horizontally projected roof area.
   f. Seismic loading requirements: As specified in Section 01612.
      1) Bolted joints subject to seismic loading shall be designated pretensioned joints

3. Deflection limitations:
   a. Primary frames:
      1) Gravity deflection:
         a) Live load deflection: $L/360$.
         b) Snow load deflection: $L/360$.
         c) Total load deflection: $L/240$.
      2) Horizontal drift of rigid frames measured at ridge indicated on the Drawings]:
a) Seismic drift limitation: \(0.015 \times H\).
b) Wind drift limitation: \(H/240\).

b. Secondary framing:
   1) Gravity deflection:
      a) Live load deflection: \(L/180\).
      b) Snow load deflection: \(L/180\).
      c) Total load deflection: \(L/150\).
   2) Horizontal deflection: \(L/180\).

c. Deflection of roof and wall panels: \(Span/180\).
d. Deflection calculations should be based on the wind loads presented in AISC Design Guide 3.

4. Climatic conditions:
   a. Gutters and downspouts: Design for a rainfall rate of 5 inches per hour.
   b. Temperature: Provide for movement (expansion or contraction) caused by a range of ambient temperature of 120 degrees Fahrenheit without detrimental effects.

5. Building Code Requirements a. The CONTRACTOR shall design the building in accordance with the requirements of CCR Title 24.

1.05 SUBMITTALS

A. Product Data:
   1. Manufacturer’s installation instructions.
   2. Manufacturer’s standard color charts and profiles:
      a. Exterior wall and roof panels.
      b. Interior wall and roof liner panels.
      c. Gutters and downspout trim.
   3. Manufacturer’s list of approved clamps that may be used to hang suspended items from roof purlins and details of acceptable methods of attachment to purlins.

B. Shop drawings:
   1. Shop drawings: Catalog cuts; design and erection drawings; and other data needed to clearly describe design, materials, construction details, fasteners, and erection.
      a. Erection drawings shall include building dimensions, required foundation footprint, anchor bolt and base plate settings, bracing, main and secondary framing, and sections and details required to fully describe construction of building.
      b. Indicate quantity, size, grade, embedment, and projection, and location of anchor bolts.
   2. Calculations: Submit engineering design calculations for the complete structural system, sealed and signed by a Structural Engineer licensed in the state where the project is located.
      a. Clearly indicate foundation reactions at all columns. Identify all applied loads, load factors, and load combinations used to develop the reactions.
      b. Calculations will be submitted for record information only.
         1) ENGINEER’s review of calculations will be for general conformance to the loading requirements of this Section.
         2) The building manufacturer shall remain fully responsible for the structural design and adequacy of the metal building system.
3. Calculations: Submit heat gain-loss calculations to demonstrate compliance with CCR Title 24.

4. Descriptive data: Submit data for the following items either on the shop drawings or separately: Accessories, each type of flashing, trim closures, caps and similar items, fasteners, doors, roof openings, gutters, and downspouts.

C. Quality control submittals:
   1. Building manufacturer.
      a. If requested by the ENGINEER, submit a record of manufacturer's metal building systems of similar design manufactured and erected in the 5-year period preceding the bid date for this project.
         1) Include date of installation, location of metal building, and name and address of OWNER.
      b. Submit evidence of manufacturer's certification under IAS AC472 Accreditation.
         1) Certification must be valid for the facility at which the metal building will be fabricated.
      c. Confirmation of UL 580 wind uplift rating.
   2. Erector:
      a. Submit welder qualification certificates.

D. Record documents:
   1. 1 set of reproducible “Record Drawings” for the erected structure.
      a. Drawings shall bear the seal and signature of a Structural Engineer, registered in the state where the work is constructed and who provided responsible charge for the design.

E. Closeout submittals: Submit Contract Closeout Submittals as specified in Section 01770.
   1. Operating and Maintenance Information.
   2. Warranty.
   3. Certificate of Compliance: At the completion of the metal building manufacture, the manufacturer will furnish a letter to the ENGINEER stating that the work was performed in accordance with the approved construction documents.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer shall have been engaged in the design, manufacture, and erection of metal building systems of the type specified for at least 5 years preceding the Bid Date of this Contract.
   1. Building manufacturer shall be certified by IAS AC472 Accreditation.
   2. The manufacturer's Engineer of Record shall hold current license as a Structural Engineer in the state where the work will be constructed.

B. Erector qualifications: Erectors shall be trained, approved, and certified by the manufacturer prior to Bidding of the Project. Erectors shall demonstrate at least 3 years experience in successfully erecting metal building systems of the type specified in Section 01610.
1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver materials and fabrications to the job site in manufacturer's original containers with seals unbroken and labeled with manufacturer's identification and number.

B. Delivery:
   1. Deliver materials dry and undamaged, and store out of contact with ground.
   2. Cover materials with weathertight coverings and keep dry.
   3. Provide good air circulation and protection from surface staining for roof and wall covering sheets.

C. Storage and protection: Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

1.08 WARRANTY

A. Provide OWNER with warranty stating that the metal building system shall be guaranteed against water leaks arising out of or caused by ordinary wear and tear by the elements for a period of 1 year from the date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Buildings: One of the following or equal:
   2. Butler Manufacturing Company.
   4. Nucor, or equal.

2.02 MATERIALS

A. Primary framing (rigid frames):
   1. Welded plates or hot-rolled steel columns and roof beams, complete with necessary splice or connector plates for bolted field assembly.
      a. Minimum nominal thickness of structural shapes or their elements shall be 1/4-inch.
   2. Welding procedures, welder qualifications, and welding quality standards shall be in accordance with AWS D1.1 and AWS D1.3.
   3. Base, cap, compression plates, and stiffener plates shall be factory-welded in place, and shall have shop-fabricated connection holes.
      a. Provide minimum 4 anchor bolts per column base.
   4. Columns and roof beams shall be fabricated complete with holes in webs and flanges for attaching bracing and roof and sidewall framing.
   5. Shop finishing:
      a. Shop galvanized - hot-dipped:
         1) Hot-dip galvanize members in accordance with ASTM A 123.
         2) Provide a minimum zinc coating of not less than 1.4 ounces per square foot.
B. Secondary framing (purlins, girts, framing at endwalls and openings, eave struts, bracing):
1. Hot rolled structural steel or cold-formed members.
3. Bracing elements constructed of wire rope, stranded tendons, or other similar material is not permitted.
   a. Rolled angle sections or solid steel bar is permitted.
4. Provide factory-punched holes for panel connections.
5. Shop finishing - hot rolled sections:
   a. Galvanized - hot-dipped:
      1) Hot-dip galvanize members in accordance with ASTM A 123.
      2) Provide a minimum zinc coating of not less than 1.4 ounces per square foot.
6. Shop finishing (cold-formed sections):
   a. Galvanized - hot-dipped:
      1) Hot-dip galvanize members in accordance with ASTM A 653 to G90 designation.

C. Roof and wall panels:
1. Roll-formed minimum 24 gauge steel.
2. Minimum 24-inch panel width with interlocking side seams.
3. Panels shall have interlocking side seams and shall be the manufacturer’s maximum standard width.
4. Factory cut to maximum possible length to minimize end laps.
5. Factory pre-punched for fastening.
6. Panel finish:
   a. Galvanized interior and exterior faces.
   b. Zinc coated to G90 coating designation in accordance with ASTM A 653.
5. Panel finish: Factory pre-painted, pre-finished coating consisting of a UV light-resistant polyvinylidene fluoride resin based paint on an approximately 55% aluminum-43% zinc-1% silicone galvanized coating. The galvanized coating shall be deposited at a minimum rate of 0.50 ounces/square foot. Furnish manufacturer’s standard color chart for OWNER’s selection.
6. Ridge panel: 1-piece, factory formed to match roof slope at each side, of same material as roof panels, and capable of completely sealing roof ridge.

D. Bolted joint components: High-strength steel bolts used for steel-to-steel structural connections.
1. Galvanized in accordance with ASTM A 153.
2. Bolts: ASTM A 325 or A 490, Type 1.
4. Washers: ASTM F 436; flat unless otherwise noted.
   a. Load indicator devices:
      1) Twist-off type tension-control bolt assemblies: ASTM F 1852, with strength level in accordance with ASTM A 325.
      2) Compressible washer direct tension indicators: ASTM F 959, Type A 325 for ASTM A 325 bolts.
5. All bolts furnished for the project shall be a single size and grade.

E. Anchor rods: Hot-dip galvanized complying with ASTM F 1554.
F. Fasteners and washers:
   1. Fasteners and washers used for attachment of wall and roof panels.
   2. Fasteners: Vinyl-coated steel or stainless steel.
   3. Washers: Neoprene or other accepted type washer capable of being used to assure watertightness at fastening locations.

G. Gutters and downspouts:
   1. 24 gauge steel.
   2. **Finish to match manufacturer’s wall panels.**
      a. Galvanized in accordance with ASTM A 653 to G60 designation.
   3. Field painted. Color to be selected by OWNER to complement wall panels.

H. Doors and frames:
   1. Provide hinged doors in accordance with published recommendations of SDI A250.8.
      a. Doors and frames shall be Level III.
   2. Provide each door with a heavy duty, corrosion resistant, cylinder lock set to match locks on Master Key System.
   3. Provide weatherstripping and threshold for exterior doors.

I. Skylights:
   1. Provide skylights as indicated on the Drawings and as specified in Section 08952.

J. Louvers:
   1. Provide louvers as indicated on the Drawings and as specified in Section 15852.

K. Touch-up painting materials:
   1. For structural elements:
      a. Shop primer: Manufacturer’s standard primer.
      b. Touch-up paint: Same as shop primer.
   2. For sheet metal skin:
      a. Exterior finish paint: Match specified coating.
         1) Color: Color as selected by the ENGINEER.

L. Insulation:
   1. **Thermal value:**
      a. Roof insulation: As required for compliance with Title 24.
      b. Wall insulation: As required for compliance with Title 24.
   2. **Thermal value:**
     a. Roof insulation, minimum thermal resistance: R-30
     b. Pump and electrical rooms wall insulation, minimum thermal resistance: R-11
   3. Provide BATT insulation in accordance with specification section 07214.

M. Caulking material: Elastomer type, manufacturer’s standard.

N. Roof vents:
   1. 10-foot ridge vents with 9 inch or 12 inch throat opening at ridge. Vents shall be pre-fabricated by a recognized manufacturer and shall include necessary flashing to make them weather tight.
2. Factory painted with color acceptable to ENGINEER and factory assembled units complete with bird screen and cord operated damper.
3. Each vent shall allow a minimum of 620 cubic feet per minute air movement at a temperature differential of 10 degrees.
4. Vents shall be fabricated by a recognized manufacturer shall include necessary flashing to make them weather tight.
5. **CONTRACTOR shall furnish number of necessary for compliance with CCR Title 24. Provide a minimum of 2 roof vents.**

O. Vent materials:
   1. Steel: Minimum 20 gauge galvanized.

P. Ventilator accessories:
   1. Bird Screen.
   2. Flashing.

2.03 FABRICATION

A. Shop fabrication:
   1. Structural elements:
      a. Fabricate rigid frame of hot-rolled sections or continuously welded plate sections.
      b. Field connections shall be bolted unless otherwise accepted by the ENGINEER.
   2. Wall panels:
      a. Provide panels that are 1 piece from base to eave and have fasteners located on inside of panels, concealed from view at the building exterior.
      b. Provide top and bottom closures and bottom supports.
   3. Roof panels:
      a. Panel splicing: Panels may be spliced with minimum end overlap of 9 inches at purlins.
      b. Ridge panel: Provide 1 piece ridge panel, factory formed to match roof slope, of same material as roof panel, and capable of completely sealing roof ridge.
      c. Expansion of roof panels: Provide means to allow expansion of roof panels.
   4. Fasteners for roof and wall panels:
      a. Fasteners: Secure with fasteners that assure maximum weathertightness, proper bearing surface, and permanent seal at point of fastening.
      b. Washers: Use washers capable of assuring watertightness at fastening locations.
   5. Accessories:
      a. Gutters, downspouts, and hangers:
         1) Provide 4-inch gutters, downspouts, and hangers as indicated on the Drawings.
      b. Vents:
         1) Provide vents of size and location indicated on the Drawings.
         2) Provide louvers that are operable and that have screens.
      c. Ventilators:
         1) Provide buildings with gravity vertical turbine ventilators with 12-inch throats where indicated on the Drawings.
2) Provide ventilators that are gravity operated with damper.
3) Accessories: Provide hardware and accessories including bird screen and flashing, as required to properly install ventilators in roof openings.

B. Tolerances:
2. Cold-formed and Built-up sections: In accordance with MBMA Metal Building Systems Manual.

2.04 SOURCE QUALITY CONTROL

A. General.
1. Components of the metal building system fabricated in the manufacturer’s shop will be subject to special inspection, as specified in Section 01455.
2. The CONTRACTOR shall communicate the proposed fabrication schedule to the ENGINEER with sufficient notice and lead time to schedule the required inspections.
3. The fabricator shall cooperate with the inspection agencies and personnel and shall facilitate access for the inspector to the components requiring inspection.
4. The inspector will verify that the fabricator maintains detailed fabrication and quality control procedures that provide a basis for inspection control of the workmanship and the manufacturer’s ability to conform to approved construction documents and referenced standards.

B. Source inspection.
1. Special inspection of the metal building system components fabricated in the manufacturer’s shop will be performed in accordance with Section 01455.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
1. Verify site conditions prior to start of work. Unacceptable conditions shall be reported to ENGINEER.
2. Starting of erection of metal building system work shall indicate acceptance of existing conditions.
   a. Manufacturer or manufacturer’s trained erector shall review and examine existing site conditions, foundation, and surface preparation, and adequacy of site-prepared components prior to commencing erection of the building.

3.02 ERECTION

A. General:
1. Erect in accordance with the MBMA, Metal Building Systems Manual and manufacturer’s instruction, except as modified in this Section.
2. Separate dissimilar materials with gaskets or suitable insulating coatings.
3. Keep exposed surfaces clean and free from sealant, metal cuttings, and other foreign materials.
B. Framing and structural members:
   1. Set anchor rods by template and securely tie into formwork before concrete placement.
   2. Provide uniform bearing under baseplates and sills by filling using a nonshrinking grout as specified in Section 03600.

C. Walls and roof:
   1. Erect a structure that will be free from water leaks and meet design requirements.
   2. Direct side lap edges away from the prevailing winds at the site.
   3. Do not exceed the maximum fastener spacings specified.
      a. Space fasteners uniformly not to exceed: 8 inches on center at ends of covering, 12 inches on center at intermediate supports and at roof covering side laps, and 18 inches on center at wall covering side laps.
   4. Install fasteners in straight lines within a tolerance of 1/2 inch per bay.
   5. Seal side laps, ends of roof, wall coverings, and joints at accessories.
      a. Drive fasteners to the surface and seat gasketed heads and washers.
   6. Fasten accessories to framing members, except as otherwise accepted by the ENGINEER.

D. Gutters and downspouts:
   1. Attach securely to the building.
   2. Install gutters sloped to drain with adequate provisions for expansion and contraction.

E. Doors and roof openings:
   1. Anchor securely to the supporting construction.
   2. Install doors plumb and true and adjust to provide operation.

F. Finishes: Complete the wall and ceiling finishes as indicated on the drawings.

3.03 FIELD QUALITY CONTROL

A. General.
   1. Installation of metal building system will be subject to special inspection and evaluation during construction, as specified in Section 01455.
   2. The CONTRACTOR shall communicate the proposed fabrication schedule to the ENGINEER with sufficient notice and lead time to schedule the required inspections.
   3. The fabricator shall cooperate with the inspection agencies and personnel and shall facilitate access for the inspector to the components requiring inspection.
   4. The inspector will verify that the fabricator maintains detailed fabrication and quality control procedures that provide a basis for inspection control of the workmanship and the manufacturer’s ability to conform to approved construction documents and referenced standards.

B. Site inspection.
   1. Special inspection of the metal building system components will be performed as specified in Section 01455.
3.04 ADJUSTING

A. Paint primed surfaces of doors and windows with 2 coats of an exterior enamel acceptable to the ENGINEER.

B. Touch-up factory finished surfaces of roof and wall panels with the manufacturer's recommended paint where damaged or abraded.

C. Where shop processes such as shearing or punching leave edges of galvanized steel unprotected by galvanization, touch up unprotected edges as specified in this Section.

D. Galvanized surfaces: Repair damaged galvanized surfaces in accordance with recommendations of the American Hot-Dip Galvanized Association and ASTM A 780. Where standards conflict, the more restrictive requirement will govern.

3.05 CLEANING

A. Remove excess materials, equipment, and debris incidental to this work upon completion.

3.06 PROTECTION

A. During erection, the erector shall be responsible for the protection of this and all adjacent work from damage.

END OF SECTION
SECTION 13446
MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve actuators.
   2. Handwheel actuators.
   3. Key operated valves.
   4. Bench stands.
   5. Floor stands.
   6. Accessory equipment and floor boxes.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45 - Designation System for Aluminum Finishes.

B. American Water Works Association (AWWA).

1.03 SUBMITTALS

A. Shop drawings: Include shop drawings for hydraulic gate lifts with shop drawings for
gates as integrated units.

1.04 QUALITY ASSURANCE

A. Provide valve actuators integral with valve or gate, except for valve actuators
   utilizing T-wrenches or keys, and portable actuators intended to operate more than
   1 valve.

B. Provide similar actuators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

1.05 MAINTENANCE

A. Extra materials:
   1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot
      shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot
      handles for operating key operated valves.
PART 2 PRODUCTS

2.01 VALVE AND GATE ACTUATORS

A. Stem covers:
   1. Aluminum pipe; threaded cap on top; bolted aluminum flange on bottom; 1- by 12-inch slots cut at 18 inches on center in front and back of pipe; capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.

B. Stem cover flanges, pipes and caps:
   1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
      a. A 41 - Clear Anodic Coating.
      b. C 22 - Medium Matte Finish.

C. Gate stem covers: Concentric with stem.

D. Position indicators:
   1. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

E. Manual or power actuator size:
   1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

F. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

G. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.

H. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

I. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.

J. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.

K. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.
L. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.02 HANDWHEEL ACTUATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Company.
   2. Waterman Industries, Incorporated.

B. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

C. Bearings above and below finished threaded bronze operating nut: Ball or roller.

D. Wheel diameter: Minimum 24 inches.

E. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

F. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

G. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

H. Grease fittings: Suitable for lubrication of bearings.

2.03 HAND-CRANKED GEARED ACTUATORS

A. Type: Single removable crank; fully enclosed.

B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

C. Operating nut: When scheduled for portable actuators.

D. Geared lifts: 2-speed with minimum ratio of 4 to 1.

E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.

F. Lift nuts: Cast manganese bronze.

G. Exterior surfaces on cast-iron lift parts: Smooth.

H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.
J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
1. Revolving brass sleeves.
2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
3. Cast manganese bronze lift nuts.
4. Cast-iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

2.04 FLOOR BOXES

A. Manufacturers: One of the following or equal:
   1. Waterman industries, Inc.

B. Floor boxes: Cast-iron; with:
   1. Counter type indicator.
   2. Hinged, lockable lid with directional arrow.
   3. 2-inch square AWWA operating nut.
   4. Packing gland providing drip-tight seal around valve shaft.

2.05 FLOOR STAND

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Company.
   2. Waterman industries, Inc.

B. Floor stand assemblies: Heavy-duty cast-iron, suitable for mounting specified actuator.

2.06 BENCH STANDS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Company.
   2. Waterman industries, Inc.

B. Bench stands: Handwheel actuators or hand crank, geared actuators conforming to hand-cranked geared actuator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

2.07 ACCESSORY EQUIPMENT

A. Wall brackets or haunches: As indicated on the Drawings.

B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.
E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.

F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.

G. Fasteners and anchor bolts: Type 316 stainless steel.

H. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

I. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.

J. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3  EXECUTION

3.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.02 SCHEDULES

A. Geared actuators: Provide geared actuators for following valves:
   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
   3. Plug valves 6 inches, nominal size, and larger.

B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.

C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION
SECTION 15050
BASIC MECHANICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.
   3. Section 01770 - Closeout Procedures.
   4. Section 01782 - Operating and Maintenance Data.
   5. Section 03600 - Grouts.
   6. Section 05120 - Structural Steel.
   7. Section 05500 - Metal Fabrications.
   8. Section 09910 - Paints.
   9. Section 09960 - Coatings.
   10. Section 10400 - Identification Devices.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   2. AGMA 6000-A88 - Specification for Measurement of Linear Vibration on Gear Units.
   4. AGMA 6019-E89 - Standard for Gear motors using Spur, Helical, Herringbone, Straight Bevel or Spiral Bevel Gears.
   5. AGMA 6025-C90 - Sound for enclosed Helical, Herringbone and Spiral Bevel Gear Drives.

B. American Society of Mechanical Engineers (ASME):
   1. ASME PTC 8.2 - Performance Test Code for Centrifugal Pumps.
   2. ANSI/ASME PTC 10 - Performance Test Code - Compressors and Exhausters.

C. American Bearing Manufactures Association (ABMA) Standards:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
D. American Society for Testing and Materials (ASTM):
5. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.

E. American National Standards Institute/Hydraulic Institute Standards (ANSI/HI):
1. ANSI/HI 1.1-1.5 - Centrifugal Pumps - Nomenclature, Definitions, Application and Operation.
2. ANSI/HI 1.6 - Centrifugal Pump Tests.
3. ANSI/HI 2.1-2.5 - Vertical Pumps - Nomenclature, Definitions, Application and Operation.
4. ANSI/HI 2.6 - Vertical Pump Tests.
5. ANSI/HI 3.1-1.5 - Rotary Pumps - Nomenclature, Definitions, Application and Operation.
6. ANSI/HI 3.6 - Rotary Pump Tests.
7. ANSI/HI 4.1-4.6 - Sealless Rotary Pumps - Nomenclature, Definitions, Application, Operation and Test.
8. ANSI/HI 5.1-1.6 - Sealless Centrifugal Pumps - Nomenclature, Definitions, Application, Operation and Test.
11. ANSI/HI 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application and Sound Measurement.

F. American National Standards Institute/American Petroleum Institute (ANSI/API):
1. ANSI/API 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

1.03 DEFINITIONS

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

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

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

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

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

F. Rotational Speed: Same as rotational frequency.
G. Maximum Excitation Frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

H. Critical Speed: Same as critical frequency.

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

**1.04 SYSTEM DESCRIPTION**

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

B. Material Requirements:
1. Materials: Suitable for superior corrosion resistance and for services under conditions normally encountered in similar installations.
2. Dissimilar Metals: Separate contacting surfaces with dielectric material.

C. Power Transmission Systems:
1. Power Transmission Equipment: V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a minimum service factor of 1.5.
   a. Apply 1.5 service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
   b. Apply service factors higher than 1.5 when recommended for continuous 24 hour-per-day operation and shock loadings specified in AGMA 6010-E88, other applicable AGMA standards, or other applicable referenced standards.
   c. When manufacturer recommends service factor greater than 1.5, manufacturer's recommendation takes precedence.

D. Vibration:
1. Resonant Frequency: Ensure there are no natural resonant torsional, radial, or axial frequencies within 25 percent above or below the operating rotational
frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.

2. Design, balance and align equipment to meet the vibration criteria specified in Section 15958.

E. Equipment Mounting and Anchoring:
1. Mount equipment on cast iron or welded steel bases with structural steel support frames. Utilize continuous welds to seal seams and contact edges between steel members. Grind welds smooth.
2. Provide bases and supports with machined support pads, dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
4. Anchor equipment base to concrete pad. Determine number, size, type, and location of bolts, anchor bolts, or other connections.
5. Provide bolt sleeves for anchor bolts for heavy equipment. Adjust bolts to final location and fill sleeve with non-shrink grout.

F. Structural Design:
1. Design connections and related details for seismic design criteria as specified in Section 01612.
2. For equipment with operating weight of 400 pounds or more provide calculations for:
   a. Determination of operating weight and centroid of equipment.
      1) Operating weight is to be weight of unit plus weight of fluids or solids normally contained in unit during operation.
   b. Determination of seismic forces and overturning moments.
   c. Determination of shear and tension forces in connections.
   d. Design of connection details based on calculated shear and tension forces.

G. Equipment Units Weighing 50 Pounds or More: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

1.05 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Product Data:
1. For each item of Equipment:
   a. Design features.
   b. Load capacities.
   c. Efficiency ratings.
   d. Material designations by UNS alloy number or ASTM Specification and Grade.
   e. Data needed to verify compliance with the Specifications.
   f. Catalog data.
   g. Name plate data.
   h. Clearly mark submittal information to show specific items, materials and accessories or options being furnished.
2. Gear Reduction Units:
a. Engineering information per applicable AGMA standards.
b. Gear mesh frequencies.

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

D. Calculations:
   1. Calculations and other information to substantiate base plates, supports, and
      anchor bolts meet minimum design strength requirements and seismic design
      criteria specified in Section 01612.
   2. Bearing L₁₀ life calculations in accordance with ABMA 9 or ABMA 11
      calculation methods for drivers, pumps, gears, shafts, motors, and other drive
      line components with bearings.
   3. Calculations and other information to substantiate that operating rotational
      frequencies meet the requirements of this Section.
   4. Torsional Analysis of Power Transmission Systems: When torsional analysis
      specified in the equipment Sections, provide:
      a. Sketch of system components identifying physical characteristics
         including mass, diameter, thickness, and stiffness.
      b. Results of analysis including first and second critical frequencies of
         system components and complete system.
   5. Calculations for connection details demonstrating compliance with specified
      structural design requirements.
   6. Require Professional Engineer registered in state where Project is located to
      stamp and sign calculations.

E. Quality Control Submittals:
   1. Source quality control reports and certified test data as specified in
      Section 15958.
   2. Submit factory test reports before shipment.
   3. Certified static and dynamic balancing reports for rotating equipment.
   4. Field quality control reports and test data as specified in Section 15958.
   5. Start-up Plan: Proposed plan for field-testing equipment as specified in
      Section 01756.
   7. Submit material test reports a specified in the equipment sections.

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

G. Project Closeout Documents: As specified in Section 01770.

1.06 QUALITY ASSURANCE

A. Manufacturer's Field Service:
   1. Furnish services of authorized representative specially trained in installation of equipment.
      a. Visit project site and perform tasks necessary to certify installation.
      b. Furnish Certificate of Proper Installation as specified in Section 01756.

1.07 DELIVERY, STORAGE, AND HANDLING

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

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

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

1.08 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Equipment for project is to be suitable for performance in outfall pump station environment and under following conditions:
      a. Ambient Temperatures: 40 to 110 degrees Fahrenheit.
      b. Relative Humidities: 50 to 100 percent.
      c. Site Elevation: Approximately 80 feet above mean sea level.

1.09 SEQUENCING AND SCHEDULING

A. Equipment Anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place when concrete is placed.
B. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. General Start-up and Testing of Equipment:
   1. Perform general start-up and testing procedures after operation and maintenance manuals for equipment have been received.
   2. Conduct functional testing of mechanical or electrical systems when each system is substantially complete and after general start-up and testing procedures have been successfully completed.
   3. Functional testing requirements as specified in Sections 01756, 13410, 15958, and 16950 and the equipment sections.

1.10 WARRANTY

A. Warranty: Warrant equipment free of defects in material and workmanship for 1 year from the date of acceptance or date of first beneficial use of the equipment by the OWNER; cover parts and labor.

B. Where an extended warranty beyond 1 year is required by the detailed equipment specification Section, manufacturer’s extended warranty shall be issued in the OWNER’s name.

1.11 MAINTENANCE

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

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

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

PART 2 PRODUCTS

2.01 MATERIALS

A. Ferrous Materials:
   1. Steel for Members used in Fabrication of Assemblies: ASTM A 36.
2. Iron Castings: ASTM A 48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
3. Galvanized Steel Sheet: ASTM A 526, minimum 0.0635 inch (16 gauge).
4. Expanded Metal: ASTM A 36, 13 gauge, 1/2-inch flat pattern expanded metal.

B. Nonferrous Materials:
1. Stainless Steel: Type 304 or 316 as specified. Provide L grade where welding required.
2. Bronze in Contact with Liquid: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C92200 or C92700 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.

C. Dielectric Materials for Separation of Dissimilar Metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials.

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

E. Non-Shrink Grout: As specified in Section 03600.

2.02 SHAFT COUPLINGS

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

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

C. Shaft Couplings - Direct Connected: Shaft couplings for direct connected electric motor driven equipment 1/2 horsepower or larger and subject to normal torque, non-reversing applications:
1. Manufacturers: One of the following or equal:
   a. Falk, WA Torus.
   b. T.B. Woods, Dura-Flex, Sure-Flex or Form-Flex.
2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
3. Provide flexible connecting element of rubber and reinforcement fibers.
4. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

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

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

2.03 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

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

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
   1. Wastewater, Water, and Sludge Applications:
      a. Asbestos free.
      b. PTFE (Teflon) free.
      c. Braided graphite.
      d. Manufacturers: One of the following or equal:
         1) Chesterton, 1400.
         2) John Crane Inc., equivalent product.
   2. Drinking Water Service:
      a. Approved by the Food and Drug Administration (FDA) or National Sanitation Foundation (NSF).
b. Asbestos free.
c. Material: Braided PTFE (Teflon).
d. Manufacturers: One of the following or equal:
   1) Chesterton, 1725.
   2) John Crane, Inc., equivalent product.

C. Mechanical Seals: Provide seal types specified in the equipment sections and as specified herein.
1. Provide seal types meeting the following requirements:
   a. Balanced hydraulically.
   b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
   c. O-Ring: Viton 747.
   d. Gland: Type 316L stainless steel.
   e. Set Screws: Type 316L stainless steel.
   g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
2. Cartridge Type Single Mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, S10.
   b. John Crane, 5610 Series.
3. Cartridge Type Double Mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, S20.
   b. John Crane, 5620 Series.
4. Split Face Single Mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, 442.
   b. John Crane, 3710.

2.04 GEAR REDUCTION UNITS

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

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

C. Planetary gear units are not to be used.

2.05 BELT DRIVES

A. Sheaves:
1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap
   tightening screws.
2. When 2 sheave sizes are specified, provide separate belts sized for each set
   of sheaves.
3. Statically balanced for all; dynamically balanced for sheaves that operates at
   peripheral speed of more than 5,500 feet per minute.
4. Key bushings to drive shaft.

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

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

### 2.06 BEARINGS

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

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

C. Grease Lubricated Bearings, Except Those Specified to Be Factory Sealed: Fit with
   easily accessible grease supply, flush, drain, and relief fittings.
   1. Lubrication Lines and Fittings:
      a. Lines: Minimum 1/4 inch diameter stainless steel tubing.
      b. Multiple Fitting Assemblies: Mount fittings together in easily accessible
         location.
      c. Use standard hydraulic type grease supply fittings.
         1) Manufacturers: One of the following or equal:
            a) Alenite
            b) Zurk.

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

### 2.07 SAFETY GUARDS

A. Drive Assemblies: Enclose sprockets, belts, drive chains, gearings, couplings, and
   other moving parts on drive assemblies in safety enclosures that are in compliance
   with applicable Laws and Regulations.
B. Shafts: Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.

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

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

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

2.08 SPRING VIBRATION ISOLATORS

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

B. Performance Requirements: Minimum spring deflection of 1 inch under static load and capable of limiting transmissability to 10 percent maximum at design operating load.

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

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

2.09 WARNING SIGNS

A. Provide for equipment that starts automatically or remotely.

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

C. Colors: Black lettering on yellow background.

D. Text: As specified in Section 10400.
2.10 FABRICATION

A. Structural Steel Members: As specified in Section 05120.

B. Nameplates:
   1. Engraved or stamped on Type 304 stainless steel and fastened to equipment at factory in an accessible and visible location.
   2. Indicate Following Information as Applicable:
      a. Manufacturer's name.
      b. Equipment model number and serial number.
      c. Maximum and Normal rotating speed.
      d. Horsepower.
      e. Rated capacity.
      f. Service class per applicable standards.

3. Nameplates for Pumps: Include:
   a. Rated total dynamic head in feet of fluid.
   b. Rated flow in gallons per minute.
   c. Impeller, gear, screw, diaphragm, or piston size.

4. Gear Reduction Units: Include:
   a. AGMA Class of service.
   b. Service factor.
   c. Input and output speeds.

C. Bolt Holes in Equipment Support Frames: Do not exceed bolt diameter by more than 25 percent, up to limiting maximum diameter oversize of 1/4 inch.

D. Shop Finishing:
   1. Provide factory and field coating as specified in Section 09960. If not specified in Section 09960, provide coating as follows:
      a. Bases and Support Frames in Contact with Concrete or Other Material:
         Coat contacting surfaces with minimum of 2 coats of zinc chromate primer before installation or grouting.
      b. Shop Primer for Steel and Iron Surfaces, Unless Specified Otherwise:
         1) Manufacturers: One of the following or equal:
            a) Ameron, Amercoat 185 Universal Primer.
            b) Cook, 391-N-167 Barrier Coat.
            c) Kop-Coat, Pug Primer.
            d) Tnemec, 37-77 Chem-Prime.
            e) Valspar, 13-R-28 Chromox Primer.
      c. Coat machined, polished, and nonferrous surfaces which are not to be painted with rust-preventive compounds.
         1) Manufacturers: One of the following or equal:
            a) Houghton, Rust Veto 344.
            b) Rust-Oleum, R-9.
      d. Coating for Ferrous Metal Surfaces, Except Stainless Steel: High solids polyamine epoxy.
      e. Finish Painting of Motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960.
2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

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

B. Concrete Surfaces Designated to Receive Grout:
   2. Clean surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bonding of grout.
   3. Concrete Saturation: Saturate concrete with water. Concrete surface shall be damp concrete at time grout is placed.

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

3.03 INSTALLATION

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

B. Lubrication Lines and Fittings:
   1. Lines from Fittings to Point of Use: Support and protect.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for Underwater Bearings: Bring fittings above water surface and mount on edge of structure above.
C. Alignment of Drivers and Equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
   2. Comply with procedures of appropriate Hydraulic Institute Standards, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
      a. Maximum Total Coupling Offset (not the per plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
      b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
   3. Use reverse-indicator arrangement dial type or laser type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
   4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation and axial spacing tolerances of the coupling.
   5. When alignment satisfies most stringent tolerance of system components, tighten anchor bolts and grout between base and foundation. Allow minimum 48 hours for grout to harden. After grout hardens, remove jacking screws, fully tighten anchor bolts, and recheck alignment. Correct alignment as required.
   6. After operational testing is complete, dowel motor or drivers and driven equipment. Comply with manufacturer's instructions.

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

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

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

G. Warning Signs: Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.
3.04 FIELD QUALITY CONTROL

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

B. Perform operational testing as required by Section 01756.

3.05 MANUFACTURER’S REPRESENTATIVE

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

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

C. Training: When training is specified, provide services of factory-trained representative to perform training as specified in Section 01756.

END OF SECTION
SECTION 15052

BASIC PIPING MATERIALS AND METHODS

PART 1    GENERAL

1.01    SUMMARY

A. Section Includes: Basic piping materials and methods.

B. Related Sections:
   1. Section 01140 - Work Restrictions.
   2. Section 09960 - Coatings.
   3. Section 15251 – Ductile Iron AWWA C151 Pipe
   4. Section 15252A – Steel Piping
   5. Section 15252C – Steel Transmission Pipelines 24 -54 Inches Diameter
   6. Section 15061 - Pipe Supports.
   7. Section 15062 - Preformed Channel Pipe Support System.

1.02    REFERENCES

A. American Society of Testing and Materials (ASTM):

1.03    DEFINITIONS

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

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

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

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

1.04    SYSTEM DESCRIPTION

A. Piping Drawings:
   1. Except in details, piping is indicated diagrammatically. Not every deflection and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
   2. The horizontal and vertical alignments shown for steel and ductile pipe transmission mains shows angles less than 5 degrees. These angles are not listed on the drawings. Contractor shall deflect and layout the pipeline joints using a maximum 2 degree angle per pipe joint. It may be necessary to deflect
multiple joints in order to meet the vertical and horizontal alignment shown on the drawings.

3. Contractor shall internally restrain pipe joints in accordance with the specifications and detail A on drawing P-25 of the contract documents when deflections are greater than 5 degrees. Thrust blocks are not allowed for restraint.

4. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
   a. Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.

5. Pipeline Drawings are identified by line and grade.

B. Performance Requirements:
   1. Venting Piping Under Pressure:
      a. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
      b. Install plug valves as air bleeder cocks at high points in piping. Provide one-inch plug valves for water lines, unless otherwise indicated on the Drawings.
      c. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling.
      d. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in accordance with Section 09960.
   2. Restraining Piping:
      a. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends.
         1) When piping is underground, use mechanical restraints.
         2) When piping is aboveground or underwater, use mechanical or structural restraints.
         3) Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
      b. Provide restraints with ample size to withstand thrust forces resulting from test pressures.
         1) During testing, provide suitable temporary restraints where piping does not require permanent restraints.
      c. Provide underground mechanical restraints where specified in the Piping Schedule.
   3. Connections to Existing Piping:
      a. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings.
   4. Connections to In-service Piping:
      a. Shutdown in-service piping in accordance with Section 01140.
         1) Establish procedures and timing in a conference attended by CONTRACTOR, ENGINEER, and OWNER of the in-service piping.
      b. Where operation and maintenance of existing facilities require that a shutdown be made during hours other than normal working hours, perform the related work in coordination with the hours of actual shutdown.
c. Additional provisions regarding shutdown of existing facilities are specified in Section 01140.

5. Connections Between Ferrous and Nonferrous Metals:
   a. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
   b. Nonferrous metals include aluminum, copper, and copper alloys.

6. Flanged Connections Between Dissimilar Metals such as Ductile Iron Pipe and Steel Pipe:
   a. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

C. Piping Alternatives:
   1. Provide piping in accordance with this Section, unless indicated on the Drawings or specified otherwise.
   2. Alternative Pipe Ratings: Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price. Piping of different material may not be substituted in lieu of specified piping.
   3. Valves in Piping Sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
   4. For flanged joints, where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

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

   B. Material: Chrome-plated steel plate.

2.02 LINK TYPE SEALS

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

   B. Characteristics:
      1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
      2. Assemble links solely with stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
      3. Provide a stainless steel or glass reinforced nylon pressure plate under each bolt head and nut. Isolate pressure plate from contact with wall sleeve.
2.03 GASKETS

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

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

2.04 FLANGE BOLTS

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

B. Steel pipe:
   1. Bolts and nuts for ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.
   2. Bolts and nuts for ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges located indoors, outdoors above ground, or in dry vaults and structures in accordance with ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 2H for nuts.
   3. Bolts and nuts for flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance
with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.

4. Provide a washer for each nut. Washer shall be of the same material as the nut.

5. Nuts shall be Heavy hex-head, Type 2H.

6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.

7. Tap holes for cap screws or stud bolts when used.

C. Lubricant for stainless steel bolts and nuts:
   1. Chloride-free.
   2. Manufacturers: One of the following or equal:

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 WALL AND SLAB PENETRATIONS

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

B. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
   1. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
   2. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
   3. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
   4. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
   5. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.

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

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

3.03 EXPOSED PIPING

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

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

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

D. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.

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

3.04 BURIED PIPING

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

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

C. Laying Piping:
1. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
2. Place piping with top or bottom markings with markings in proper position.
3. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
4. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
5. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

3.05 CLEANING

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

3.06 PIPING SCHEDULE

A. Abbreviations:
1. The following abbreviations used in the column of test method refer to the respective methods specified in Section 15956.
   AM Air method
   GR Gravity method
   HH High head method
   LH Low head method
   SC Special case
2. Abbreviations to designate piping include the following:
   CI Cast iron
   CI Class, followed by the designation
   CM Cement mortar
   DIP Ductile iron piping
   PEE Polyethylene encasement
   Ga Gauge, preceded by the designation
   GE Grooved end joint
   NPS Nominal pipe size, followed by the number in inches, pounds per square inch, or pounds per square inch, gauge.
   EPP Epoxy and polyurethane coating system per Section 09960
   PVC Polyvinyl Chloride
   RCP Reinforced Concrete Pipe
<table>
<thead>
<tr>
<th>Sch.</th>
<th>Schedule, followed by the designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>VCP</td>
<td>Vitrified clay piping</td>
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</table>

(The PIPING SCHEDULE follows in the next pages.)
## PIPING SCHEDULE

<table>
<thead>
<tr>
<th>Code</th>
<th>Service</th>
<th>Exposure</th>
<th>Nominal Size (inches)</th>
<th>Min</th>
<th>Max</th>
<th>Materials</th>
<th>Joints / Fittings</th>
<th>Test Pressure / Method</th>
<th>Thickness or Class</th>
<th>Lining</th>
<th>Coating</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>FE</td>
<td>Final Effluent</td>
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<td></td>
<td></td>
<td>RCP –Jacked</td>
<td>Push-on Joint</td>
<td>25 Feet / GR</td>
<td>D-25</td>
<td>N/A</td>
<td>N/A</td>
<td>Per Sections 02600 &amp; 15261. In between Junction Box &amp; Pump Station.</td>
</tr>
<tr>
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<td>Buried</td>
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<tr>
<td></td>
<td></td>
<td>RCP</td>
<td>25 Feet / GR</td>
<td></td>
<td></td>
<td>Thickness &gt;6”</td>
<td></td>
<td>DIP Class 150</td>
<td>CM</td>
<td>Per</td>
<td>Section</td>
<td>Per Sections 02318 &amp; 15261. In between standpipe structure and outfall structure. RCP joint shall be secured with hoop steel and reinforce concrete within the leave.</td>
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<tr>
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<td>Buried</td>
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<td>Thickness &gt;6”</td>
<td>ATM C76-90</td>
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<td></td>
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<td>DIP</td>
<td>100 psig/HH</td>
<td></td>
<td></td>
<td>DIP Class 150</td>
<td></td>
<td></td>
<td>CM</td>
<td>Per</td>
<td>Section</td>
<td>For pipe between stations 10+36.99 to 305+00 (Pipe must be restrained at bends as called out on Drawing P-25). See Drawings and Specifications for further requirements.</td>
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<td>100 psig/HH</td>
<td>AWWA C-200</td>
<td>CM</td>
<td>CM</td>
<td>For pipe between 10+36.99 to 305+00 (Pipe joints must be welded at bends as called out on Drawing P-25 or where called out on drawings).</td>
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<td>Steel Pipe</td>
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<td>Welded Joint</td>
<td>100 psig/HH</td>
<td>AWWA C-200</td>
<td>CM</td>
<td>CM</td>
<td>All yard piping on pump station and standpipe structure sites. Provide cathodic isolation at connection to transmission main at stations 10+36.99 and 305+00.</td>
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## PIPING SCHEDULE

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<th>Joints / Fittings</th>
<th>Test Pressure / Method</th>
<th>Thickness or Class</th>
<th>Lining</th>
<th>Coating</th>
<th>Remarks</th>
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<td>DIP</td>
<td>Restrained Push-on Joint</td>
<td>100 psig /HH</td>
<td>DIP Class 150</td>
<td>CM Per Section 15251</td>
<td>CM Per Section 15251</td>
<td>For piping associated with Typical Details P802 and P804, except where otherwise indicated on the Drawings. See Drawings and Specifications for additional requirements.</td>
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<td>DIP</td>
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<td>100 psig/ HH</td>
<td>Class 53</td>
<td>CM Per Section 15251</td>
<td>Per Section 15251</td>
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<td>Steel Pipe</td>
<td>Welded Joint</td>
<td>100 psig/ HH</td>
<td>AWWA C-200</td>
<td>CM</td>
<td>CM</td>
<td>Pipeline from standpipe structure to RCP pipe at San Joaquin River levee.</td>
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Min. thickness 0.50 inches (150 psi pressure rated)
## Piping Schedule

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<td>AWWA C-200 (150 psi rated) min thickness 0.25 inches</td>
<td>Fusion Bonded Epoxy per 15057</td>
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<td>Exposed (In Vaults)</td>
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SECTION 15057
FUSION BONDED EPOXY LINING

PART 1 GENERAL

1.01 SUMMARY
A. Section includes: Fusion bonded epoxy lining for steel or ductile iron pipe and fittings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES
A. ASTM International (ASTM):

B. AWWA C213-07 - Fusion bonded epoxy coating for the interior & exterior of steel water pipelines.

C. Society for Protective Coatings (SSPC):
   1. SSPC-SP 10 - Near-White Blast Cleaning.

1.03 SUBMITTALS
A. Product data.

B. Test reports: Include manufacturer’s certification that lining passed tests.

C. Manufacturer’s application instructions.

PART 2 PRODUCTS

2.01 EPOXY RESIN POWDER
A. Manufacturer: One of the following or equal:
1. 3M.

B. Material: Thermosetting, fusion bonded dry powder epoxy, 100 percent solids, with following performance characteristics when applied:
   1. Cathodic disbondment resistance: Average maximum 48 millimeters when tested in accordance with ASTM G 8.
   2. Adhesion shear resistance: Minimum 4,700 pounds per square inches when tested in accordance with ASTM D 1002.

2.02 FABRICATION

A. Blast fitting interior surfaces of pipe and fittings in accordance with SSPC-SP 10.

B. Apply epoxy resin powder to blasted surfaces by either fluidized bed method or electrostatic coating method to obtain minimum 16-mil thick lining in accordance with manufacturer's instructions.

C. Fuse lining to piping in accordance with manufacturer's instructions.

2.03 SOURCE QUALITY CONTROL

A. Test lining with either 100 volt per mil thickness holiday detectors or low voltage wet sponge holiday detectors.

B. Reject pipe and fitting with linings that contain pinholes, discontinuities or other defects.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pipe and fitting as specified in Section 15052.

END OF SECTION
SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   1. Section 05120 - Structural Steel.
   2. Section 09960 - High Performance Coatings.

1.02 REFERENCES

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

1.03 SUBMITTALS

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

PART 2 PRODUCTS

2.01 PIPE SUPPORTS

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

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

C. Hanger Rods: Sized to match suspended pipe hanger, or as indicated on the Drawings.
   1. Manufacturers: One of following or equal:
      a. Grinnell, Figure 140.
      b. Bergen-Paterson, Part 5000.
      c. B-Line Systems, Inc., Figure B3205.
D. Hanger Rods, Continuously Threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings.
   1. Manufacturers: One of the following or equal:
      a. Grinnell, Figure 146.

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

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

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

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

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

J. Single Rod Hangers for Steam Pipe: ANSI/MSS SP 69 Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod.
   1. Manufacturers: One of the following or equal:
      a. Grinnell, Figure 181.
      b. B-Line Systems, Inc., Figure B3110.

K. Double Rod Hangers for Steam Pipe: ANSI/MSS SP 69 Type 41:
   1. Manufacturers: One of the following or equal:
      a. Grinnell, Figure 171.
      b. B-Line Systems, Inc., Figure B3114.

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

   1. Manufacturers: One of the following or equal:
      a. Grinnell, Figure 137.
      b. Bergen-Paterson, Part 6510.
      c. B-Line Systems, Inc., Figure B3188.
N. Riser Clamps: ANSI/MSS SP-69 Type 8.
   1. Manufacturers: One of the following or equal:
      a. Grinnell, Figure 261.
      b. Bergen-Paterson, Part 6302.
      c. B-Line Systems, Inc., Figure B3373.

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

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

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

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

S. Spring Supports:
   1. Manufacturers: One of the following or equal:
      b. Grinnell, Figure B-268.

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

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

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

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

A. Pipe Supports:
   1. Stainless Steel (Type 304 or 316): Use in all submerged locations, above water level but below top of wall inside water bearing structures and where specifically indicated on the Drawings.
   2. Hot-Dip Galvanized Steel: Use in areas other than above and where specifically indicated on the Drawings. Hot-dip galvanize pipe support after fabrication.

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

PART 3 EXECUTION

3.01 INSTALLATION

A. Properly support, suspend or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

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

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

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

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

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

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

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

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

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

K. Support Spacing:
   1. Support 2 inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2 inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet
on center, regardless of size.

4. Support tubing, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.

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

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

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

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

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

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

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

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

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

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

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

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

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

END OF SECTION
SECTION 15062
PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. American National Standard Institute/Manufacturer’s Standardization Society (ANSI/MSS):
   2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

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

B. Design Criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   3. Allowable Stress of Channels:
      a. Steel Channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
      b. Stainless Steel Channels: 0.66 times the yield stress of the stainless steel alloy.
   5. Allowable Column Loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   6. Future Loads:
      a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
7. Seismic Design Criteria: As specified in Section 01612 as specified for mechanical equipment.
8. Spacing of Supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the Top of Walls of Water Bearing Structures: Use Type 304 stainless steel for support system components.
   1. Supports in Other Locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.04 SUBMITTALS

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

B. Structural Design Calculations.

1.05 QUALITY ASSURANCE

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

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501, as indicated on the Drawings.
      b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
      c. B-Line Systems, Inc., Channel Type B22 or B22A; B12 or B12A.

2.02 ACCESSORIES

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

B. 90 Degree Angle Fittings:
1. Manufacturers: One of the following or equal:
   a. Unistrut, P1026.

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

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

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

2.03 FABRICATION

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

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

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

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

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

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

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

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

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

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

END OF SECTION
SECTION 15075
MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   1. Section 01600 - Product Requirements.
   2. Section 01770 - Closeout Procedures.
   3. Section 09960 - Coatings.

1.02 REFERENCES

A. American National Standards Institute (ANSI):

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   2. Lab Safety Supply.

2.02 MATERIALS

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

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Lettering Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1.5</td>
<td>1/2 inch</td>
</tr>
<tr>
<td>1.5 inches to 2 inches</td>
<td>3/4 inch</td>
</tr>
<tr>
<td>2.5 inches to 6 inches</td>
<td>1-1/4 inches</td>
</tr>
<tr>
<td>8 inches to 10 inches</td>
<td>2-1/2 inches</td>
</tr>
<tr>
<td>Over 10 inches</td>
<td>3-1/2 inches</td>
</tr>
</tbody>
</table>

### 2. Marker Colors:

<table>
<thead>
<tr>
<th>Service</th>
<th>Lettering</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammables, chemicals, toxics</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Water, nontoxic solutions or low hazard liquids</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Nonflammable or nontoxic gases</td>
<td>White</td>
<td>Blue</td>
</tr>
<tr>
<td>Fire quenching fluids (foam, fire water, CO2 Halon)</td>
<td>White</td>
<td>Red</td>
</tr>
</tbody>
</table>

### B. Coating:
As specified in Section 09960.

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

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

### E. Snap-on Markers:
Markers with 3/4 inch high letters for 3/4 to 4 inch pipe or covering, or 5 inch high letters for 5 inch or larger pipe or cover, as manufactured by one of following:
2. Seton Setmark.

### 2.03 SPECIAL ITEMS

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve handwheels and levers</td>
<td>Red</td>
</tr>
<tr>
<td>Hoist hooks and blocks</td>
<td>Yellow and black stripes</td>
</tr>
<tr>
<td>Steel guard posts</td>
<td>In accordance with standard details.</td>
</tr>
</tbody>
</table>

#### B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are identified on Drawings or in Specifications by number.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

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

3.02 PREPARATION

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

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

3.03 PIPING IDENTIFICATION

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

B. Color Code:
   1. Coat piping scheduled to be color coded completely with specified colors.
   2. Coat segments of pipe specified to be unpainted with specified coding color long enough to accommodate required lettering and arrows.

C. Coat piping specified to be coated to match adjacent surfaces, unless otherwise directed.

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

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

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

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

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

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

C. Provide piping marker letters and colors as scheduled.

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

3.05 PIPING COLOR CODE AND MARKER SCHEDULE

<table>
<thead>
<tr>
<th>Service Fluid</th>
<th>Pipe Color</th>
<th>Marker Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Effluent Light Blue</td>
<td>FE</td>
<td></td>
</tr>
<tr>
<td>Final Effluent Light Blue</td>
<td>SERVICE WATER</td>
<td></td>
</tr>
<tr>
<td>Drain Charcoal</td>
<td>DRAIN</td>
<td></td>
</tr>
<tr>
<td>Exhaust Gas Yellow</td>
<td>EXHAUST GAS</td>
<td></td>
</tr>
<tr>
<td>Engine Jacket Water Dark Blue</td>
<td>ENGINE JACKET WATER</td>
<td></td>
</tr>
<tr>
<td>Fuel Oil Orange</td>
<td>FUEL OIL</td>
<td></td>
</tr>
<tr>
<td>Pumped Drain Charcoal</td>
<td>PUMPED DRAIN</td>
<td></td>
</tr>
<tr>
<td>Sample Green</td>
<td>FLUID BEING SAMPLED</td>
<td></td>
</tr>
<tr>
<td>Vent Pipe Yellow</td>
<td>VENT PIPE</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Letters</th>
<th>Color of Pipe</th>
<th>Color of Bands</th>
<th>Color of Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>FE</td>
<td>Light blue</td>
<td>None</td>
<td>Black</td>
</tr>
<tr>
<td>Sample</td>
<td>Dark Blue</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Red</td>
<td>None</td>
<td>Black</td>
</tr>
<tr>
<td>Hydrants</td>
<td>Aluminum</td>
<td>None</td>
<td>Black</td>
</tr>
<tr>
<td>Wash Water Drain</td>
<td>Light Gray</td>
<td>None</td>
<td>Black</td>
</tr>
<tr>
<td>Drain</td>
<td>Dark Gray</td>
<td>None</td>
<td>White</td>
</tr>
<tr>
<td>Stainless Steel Pipe</td>
<td>White</td>
<td>Red</td>
<td>White</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 15084
DUCTWORK INSULATION

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes: Internal acoustical insulation and external thermal insulation for metal air ductwork systems.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM):
B. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
   1. HVAC Duct Construction Standards, Metal and Flexible Ducting.
C. Uniform Mechanical Code (UMC).

1.03 SUBMITTALS
A. Submit in accordance with Section 01330.
B. Manufacturer's product literature including product specifications and installation recommendations.

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

PART 2 PRODUCTS

2.01 INTERNAL DUCTWORK INSULATION
A. Manufacturers: One of the following or equal:
   1. Owens Corning, Aeroflex Plus.
B. Type: Flexible or board type duct liner with 1 coated surface meeting the following:
   1. Thickness: As required to achieve the following R values:
      a. For exterior ducting, 1.5 inches minimum to meet R 6.3; provide weatherproof exterior barrier.
b. For interior ducting in plenums, attics or other unconditioned spaces
   1.0 inches minimum to meet R 4.2
2. Temperature Range: 40-250 degrees Fahrenheit.
3. Density: 3/4 pounds per cubic foot.
4. Thermal Conductivity: 0.25 Btu-inch per hour per square foot per degree
   Fahrenheit at 75 degrees Fahrenheit.
5. Fire hazard classification as determined by ASTM E 84:
   c. Smoke Developed: 50.
6. Service Conditions: Velocities to 2,500 feet per minute.
7. Acoustical Performance: NRC of 0.7 minimum.

C. Edge Treatment: Provide leading edges with galvanized metal nosing; seal other
   edges with manufacture's recommended edge treatment.

PART 3 EXECUTION

3.01 INTERNAL DUCTWORK INSULATION

A. Install with coated surface facing inside of duct; attach with adhesive to duct and
   provide fasteners spaced at not to exceed 12 inches transverse (perpendicular) to
   flow and 18 inches parallel (longitudinal) to flow; provide fasteners within 3 inches of
   transverse edges and 4 inches of longitudinal edges.

B. Follow manufacturer's published installation instructions.

C. Install metal nosing on leading edges and seal other exposed edges with
   manufacturer's edge treatment.

END OF SECTION
SECTION 15110

VALVES

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes: Basic requirements for valves.

B. Related Sections:
   1. Section 09960 - Coatings.
   2. Section 15052 - Basic Piping Materials and Methods.
   3. Section 15251 - Ductile Iron Piping.

1.02  REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   1. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.

B. American Society for Testing and Mater (ASTM):

C. American National Standards Institute/American Water Works Association (ANSI/AWWA):

D. American Water Works Association (AWWA):

E. SSPC – Society for Protective Coatings:
   1. SSPC SP 2 - Surface Preparation Specification for Hand Tool Cleaning.
   2. SSPC SP7 - Brush-Off Blast Cleaning.

1.03  DESIGN REQUIREMENTS

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

B. Valve to Piping Connections:
   1. Valves 3 Inch Nominal Size and Larger: Flanged ends.
   2. Valves less than 3 Inch Nominal Size: Screwed ends.
   3. Plastic Valves in Plastic Piping:
      a. Up to 2.5 Inches: Provide solvent or heat welded unions.
      b. 3 Inches and Above: Provide solvent or heat welded flanges.

1.04 SUBMITTALS

A. Submit in accordance with Section 01330.

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

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

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY STORAGE AND HANDLING

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

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless Steel: ASTM A 167, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and Operator Bolts and Nuts:
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground Bolts: Low-alloy steel in accordance with AWWA C 111/A21.11.
C. Bronze and Brass Alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

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

2.02 INTERIOR PROTECTIVE LINING

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

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

C. Lining Types:
   1. Fusion Bonded Epoxy:
      a. Manufacturers: One of the following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces to meet SSPC SP-7 or SP-10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining Thickness: 0.010 to 0.012 inches except that:
         1) Lining Thickness in Grooves for Gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality Control:
         1) Lining Thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
         4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.
   2. High Solids Epoxy:
      a. Product: As specified in Section 09960A.
         1) Certified to NSF 61 for drinking water use.
      b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
      c. Apply coating in accordance with Section 09960A and coating manufacturer’s recommendations.
      d. Quality Control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
         1) Repair holidays and other irregularities and retest coating.
         2) Repeat procedure until holidays and other irregularities are corrected.
2.03 UNDERGROUND VALVES

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

B. Coating and Wrapping:
   1. Prior to installation, coat buried valves with 2 coats of protective coal tar in accordance with Section 09960A.
   2. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15251.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 VALVE BOXES

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

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

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

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

2.05 VALVE OPERATORS

A. Valve Operator "Open" Direction: Open counterclockwise.

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

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

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.
E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inch square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

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

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

3.02 INSTALLATION

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

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

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

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

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

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

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

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

END OF SECTION
SECTION 15111
BALL VALVES

PART 1  GENERAL

1.01  SUMMARY
A. Section includes: Metal body ball valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 13445A - Hydraulic and Pneumatic Cylinder Operators.
      c. Section 13445B - Pneumatic Controllers and Control Valves.
      d. Section 13447 - Electric Motorized Actuators.
      e. Section 15052 - Common Work Results for General Piping.
      f. Section 15110 - Common Work Results for Process Valves.

1.02  REFERENCES
A. American Society of Mechanical Engineers (ASME):

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

C. ASTM International (ASTM):

1.03  SYSTEM DESCRIPTION
A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.
B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

1.04 SUBMITTALS

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

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, 6 INCH SIZE AND LARGER

A. Manufacturers: One of the following or equal:
   1. APCO Willamette: Metal seated valve.
   2. GA Industries: Metal seated valve.

B. General:
   1. Type: Non-lubricated, metal seated and capable of sealing in either flow direction.
   2. In accordance with AWWA C507.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. ASME B16.1, Class 125 flanged ends.

C. Materials:
   1. Body: ASTM A 48 cast iron with 400 series Monel seats and integrally cast bronze bushed trunnions.
   2. Ball: Type 304 or Type 316 stainless steel.
   4. Stem seals: PTFE or Viton.

D. Valve actuator:
   1. Manually operated valves: Self-locking worm gear type actuator with position indicator. Permanently lubricate gearing. Provide adjustable screws to stop travel at both open and closed positions.

2.02 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Apollo Valves as manufactured by Conbraco Industries, Inc.
   3. NIBCO, Inc.

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

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

PART 3 EXECUTION

3.01 INSTALLATION

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

END OF SECTION
SECTION 15112
BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Metal body butterfly valves.

B. Related Sections:
   1. Section 01330 - Submittal Procedures.
   2. Section 09960 - Coatings.
   3. Section 15050 - Basic Mechanical Materials and Methods.
   4. Section 15052 - Basic Piping Materials and Methods.
   5. Section 15110 - Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers / American National Standards Institute/ (ASME/ANSI):
   2. ASME/ANSI B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Society for Testing and Materials (ASTM):
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes
   4. A351 - Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts
   6. A479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
   8. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
   10. A564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardenable Stainless Steel Bars and Shapes

C. American Water Works Association (AWWA):
   5. C606 - Standard for Grooved and Shouldered Joints.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. General Purpose AWWA Butterfly Valves:
      a. Design Standard: Provide valves designed and manufactured in accordance with AWWA C504.
      b. Class:
         1) Provide butterfly valves conforming to AWWA Class 150B, unless otherwise specified.
         2) Provide butterfly valves conforming to AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch and less than 250 pounds per square inch.

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

C. Design Requirements for all Butterfly Valves:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      b. Maximum Pressure Differential Across the Closed Valve: Equal to the pressure class designation.
      c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.
   2. Valve Disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions.
      a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
   3. Unacceptable Thrust Bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

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

1.04 SUBMITTALS

A. Shop Drawings: Submit information specified in Section 01330 and Section 15050 and the following:
   1. Certified drawings and material specifications.
   2. For General Purpose AWWA Butterfly Valves, include description of the method of attachment of the disc edge to the valve disc.

B. Product Data: Include manufacturer's published recommendations for seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.

C. Certificates:
   1. General Purpose AWWA Butterfly Valves:
      a. Proof-of-Design Tests: Certified statement that proof-of-design tests were performed and all requirements were successfully met.
      b. Affidavit of compliance attesting valves provided comply with all provisions of AWWA C504.
   2. Interior Epoxy Coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions of AWWA C550.
   3. Certification, for all valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF/ANSI Standard 61.

PART 2 PRODUCTS

2.01 GENERAL PURPOSE AWWA BUTTERFLY VALVES

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

B. Valve Body:
   2. Body Design:
      a. Flanged Body Valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
      b. Mechanical Joint Body Valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Mechanical Joint Design: Conform to AWWA C110.
         3) When mechanical joint body valves are used, incorporate valve into thrust restraint analysis required by Section 15251. Utilize test
pressure on one side of valve and zero pressure on the opposite side of the valve. Restrain pipe joints on both sides of valve as determined by thrust analysis calculations.

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

D. Shaft and Bearings:
1. Shaft Design:
   a. Valves 20-inch and less: One piece, through disc design.
   b. Valves greater than 20-inch size: Two piece, stub shaft design.
2. Shaft Seal: Vee type, chevron design.
4. Shaft Material for Class 250B Valves: Type 17-4 pH stainless steel, ASTM A564.
5. Shaft Bearings: Self-lubricating sleeve type; Teflon with stainless steel or fiberglass backing.

E. Seats:
1. Seat Materials: NBR.
2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive.
   a. Mechanical Retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
      1) Clamping ring, ring locks and adjusting locking screws: Type 316 stainless steel.
      2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
   b. Adhesive Retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
   c. Do not provide valves with seats retained by snap rings or spring loaded retainer rings.
4. Resilient Seat: Withstand 75 pound per inch pull when tested in accordance with ASTM D429, Method B.

F. Valve Packing:
1. Valves 4 Inch to 48 Inch Nominal Size: Self-adjusting V-type packing or chevron-type packing. NBR.
2. Valves 54 Inch Nominal Size and Larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-type packing. NBR.

2.02 BUTTERFLY VALVE ACTUATORS

A. Requirements for manual actuators are in Section 13446.
B. Manual Actuators for Aboveground Valves, 4 Inches in nominal size and smaller for Liquid Service, and 10 Inches in nominal size and smaller for Aeration Air Service:
   1. For valves operating at pressures up to and including 250 pounds per square inch, provide hand lever type with locking device so that the valve can be locked in any position with a wing nut.
      a. Locking Device: Rigid, allowing no vibration or chattering of the valve.
      b. Hand Lever: 12 inches long, with hand grip.
   2. For valves operating at pressures above 250 pounds per square inch, provide totally enclosed worm gear actuator mounted on the valve.

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

D. Manual Actuators for Aboveground Valves 30 Inches in nominal size and larger, all pressures:
   1. Provide totally enclosed worm gear actuator mounted on the valve.

E. Manual Actuators for Buried or Submerged Valves, All Sizes and Pressures:
   1. Provide totally enclosed worm gear actuator mounted on the valve.
   2. Actuators for buried or submerged valves shall be hermetically sealed and grease packed.
   3. For buried valves, provide 2-inch square AWWA nut on enclosed actuator.
   4. For buried valves, provide extension stem, valve box and valve box cover in accordance with Section 15110.
   5. For submerged valves, provide extension stem as indicated on the Drawings.

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

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

2.03 COATING

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

B. Coating Material for Potable Water Applications:
1. Formulate coating material from materials accepted by the Food and Drug Administration, Title 21 of the Code of Federal Regulations on Food Additives.

C. Field Applied Coatings:
   1. Additional coating of the valve exterior will be required to match the epoxy or epoxy/polyurethane paint system called for in Section 09960.
      1) When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
      2) When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

D. Surface Coatings:
   1. Interior surfaces: High solids epoxy.
   2. Exterior Surfaces of Valves, Actuators and Accessories:
      b. Buried Valves: Coal tar epoxy.
      c. Other Valves: High solids epoxy.

E. Coating Materials:
   1. High Solids Epoxy and Coal Tar Epoxy:
      a. Products: As specified in Section 09960.
         1) Coating product in contact with potable water must be acceptable under AWWA C550 and NSF-61.
      2. High Temperature Coating: In accordance with Section 09660 and AWWA C550.
      3. Rust-Preventive Compound: One of the following or equal:
         a. Houghton, Rust Veto 344.
         b. Rust-Oleum, R-9.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

END OF SECTION
## BUTTERFLY VALVE APPLICATION SCHEDULE

<table>
<thead>
<tr>
<th>Valve Type and Style</th>
<th>Acceptable Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose AWWA Butterfly Valves – Flanged Body Design</td>
<td>Aboveground or submerged in the following service applications only:</td>
</tr>
<tr>
<td></td>
<td>May be used in buried applications when required by the specified piping system.</td>
</tr>
<tr>
<td>General Purpose AWWA Butterfly Valves – Mechanical Joint Body Design</td>
<td>Buried in the following service applications only:</td>
</tr>
<tr>
<td></td>
<td>Acceptable in all service applications except oxygen and ozone service and high pressure service.</td>
</tr>
</tbody>
</table>
SECTION 15114
CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes: Swing and cushioned swing.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM):
B. American Water Works Association (AWWA):
   1. C 508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.

1.03 SYSTEM DESCRIPTION
A. Design Requirements:
   1. Check Valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
      a. In either horizontal or vertical position.
      b. Under pressures equal and less than 150 pounds per square inch gauge.
   2. Provide calculations for air damper assembly sizing.

PART 2 PRODUCTS

2.01 SWING CHECK VALVES
A. Valves 1/4 Inch through 3 Inch:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Company, Number 36.
      b. Lunkenheimer Company, Figure 554Y.
   2. Valve Design:
      a. Threaded joints.
      b. Y-pattern body with integral seat.
      c. Hinged disc.
      d. Access to valve seat for regrinding without disassembly of piping.
   3. Materials:
      a. Body, Cap, Hinge, and Disc: Bronze
2.02 CUSHIONED SWING CHECK VALVES

A. Valves 3 inch and greater:
   4. Manufacturers: One of the following or equal:
      a. APCO, Steel Swing-Check, Series 6000B.

B. Valve Design:
   1. Counter-weighted.
   2. Rubber seated and drip tight.
   3. Pneumatic dampening chambers with adjustment for closing speed.

C. Materials:
   1. Valve Body, Cover, and Disc: Cast-iron, ASTM A 126, Class B.
   2. Disc seat: Buna N.
   5. Disc Ring Seat: Bronze.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Upon installation the CONTRACTOR shall open a check valve for inspection of internal coating.
3.02 ADJUSTING

A. Adjust cushioned swing check valves in the field by means of external adjustment devices to minimize pressure surges.

B. Adjust weight on swing check valves to affect proper closing action on equipment shutdown.

END OF SECTION
SECTION 15115
GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes: Gate, plain hose valves, and yard hydrants.
B. Related Sections:
   1. Section 15110 - Valves.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM):
   1. B 98 - Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
B. American Water Works Association (AWWA):
   1. C 509 - Standard for Resilient-Seated Gate Valves for Water-Supply Service
      (includes addendum C509a-95).

PART 2 PRODUCTS

2.01 GATE VALVES
A. Gate Valves Aboveground:
   1. Valves less than 3 Inches in Size for Clean Water and Air Service:
      Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end,
      Class 150 pounds.
      a. Manufacturers: One of the following or equal:
         1) Crane, Figure 431.
         2) Jenkins, Figure 47.
         3) Lunkenheimer Company, Figure 2151.
   2. Valves 3 Inches in Size and Larger:
      a. Resilient wedge type in compliance with AWWA C509.
      b. Flange, iron body and bonnet rated for 200 pound working pressure.
         Provide O-ring seal between valve body and bonnet.
      c. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of
         sealing in either flow direction.
      d. Bronze stem with double or triple O-ring or braided packing stem seals.
      e. Rising stem configuration with handwheel diameter sized to allow opening
         of valve with no more than a 40 pound pull.
      f. Coat interior and exterior surfaces of valve body and bonnet with fusion
         bonded epoxy in accordance with AWWA C550.
      g. Manufacturers: One of the following or equal:
         1) M&H/Kennedy Valve Company, Style 4068.
         2) Mueller, 2360 Series.
         3) American Flow Control, Series 500.
B. Gate Valves Underground:
   1. Resilient wedge type in compliance with AWWA C509.
   2. Iron body, resilient seat, non-rising stem, double O-ring stem seal.
   3. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
   4. Bronze stem with double or triple O-ring or braided packing stem seals.
   5. Coat interior and exterior surfaces of valve body and bonnet with fusion bonded epoxy in accordance with AWWA C550.
   6. Valve Operator: Provide standard AWWA 2-inch operating nut, matching valve key and valve box for operating stem.
   7. Manufacturers: One of the following or equal:
      a. M&H/Kennedy Valve Company.
      b. Mueller Company.
      c. American Flow Control.

2.02 HOSE VALVES AND YARD HYDRANTS

A. Hose Valves:
   1. Manufacturers:
      a. Globe Threaded Valve: One of the following or equal:
         1) Crane, No. 7TF.
         2) Stockham, Figure No. B22T.
      b. Angle Threaded Valve: One of the following or equal:
         1) Crane, No. 17TF.
         2) Stockham, Figure No. B222T.
   2. Design:
      a. Valve: Globe or angle valve with threaded ends size 1/8 inch to 3 inches in diameter, size as indicated on the Drawings.
      b. Disc: Renewable, made of Teflon or Buna-N.
      c. Threaded ends, rated for a pressure of 200 pounds per square inch.

B. Freezeless Yard Hydrant:
   1. Manufacturers: One of the following or equal:
      a. Josam, Series 71700.
      b. Zurn, Z-1385.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Mount yard hydrants on iron pipe risers minimum 1 inch nominal diameter or size indicated on the Drawings.

END OF SECTION
SECTION 15119
AIR AND VACUUM RELIEF VALVES

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes: Air release valves, air and vacuum valves, and air vents.

B. Related Sections:
   1. Section 15110 - Valves.

1.02  REFERENCES

A. American Society for Testing and Materials (ASTM):

1.03  SUBMITTALS

A. Product Data: Detailed technical information relating to each type of valve including description of component parts, materials of construction, performance information, dimensions and weights.

B. Operations and Maintenance Data: Furnish bound sets of installation, operation and maintenance instructions for each type of valve.

PART 2  PRODUCTS

2.01  AIR RELEASE VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:

B. Design:
   1. Pressure Rating: 150 pounds per square inch gauge.
   2. Inlet: Screwed, 2-inch.
   3. Orifice Size: 1/4 inch diameter.

C. Materials:
   1. Valve Body: Cast iron.
   2. Float and Internal Trim: Stainless steel.
   3. Seat or Valve Plunger: Buna-N.
2.02 AIR AND VACUUM SLOW CLOSING VALVE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, APCO, Series 1200 slow closing air and vacuum valve.
   2. Val-Matic, equivalent product.

B. Design:
   1. Valve: An assembly of 4 valves tested as a single unit.
   2. Air and Vacuum Valve: To include a stainless steel float guided at each end with stainless stems.
   3. Stems: Guided through stainless steel bushings inside the body and cover.
   4. Seat: Fastened to the cover with stainless shoulder screws without distortion to allow drip-tight closure.
   5. Cover: To include a male lip to fit the female body register for positive float guide direction into the seat.
      a. Cover outlets may be hooded.
   6. Surge Check Valve: A normally open spring loaded valve consisting of a body, seat and plug bolted to the inlet of the air and vacuum valve.
   7. Surge Check: Operate on the interphase between the kinetic energy and relative velocity flows of air and water, allowing air to pass through, but water shall close the surge check, reducing the rate of water flow by means of throttling orifices in the plug to prevent shock closure of the air and vacuum valve.
   8. Surge Check Orifices: Adjustable type to suit operating conditions in the field.
   9. Inlet Isolation Butterfly Valve: Wafer (compact) style manufactured in accordance with AWWA Standards with hand lever and variable position locking device.
      a. Seat: Freely interchangeable from the body without need for special tools or skill.
      b. Seat: Buna N, molded with a steel flanged insert for high strength and tight seating.
      c. Disc: Pivot eccentrically from closed position to clear center valve area.
   10. Air Release Valve: Side connected to the upper valve but separated with a bronze isolation shutoff valve.
   11. Internal Mechanism: The compound lever type to permit the valve to open under pressure to vent pockets of entrapped air as they accumulate.
      a. Compound Mechanism: Activated by a stainless steel concave float to lift the Buna N needle to shut off the air release orifice.

C. Materials:
   1. Certified to meet ASTM specifications specified herein.
   2. Air and Vacuum Valves, and Air Release Valve Covers and Bodies, Surge Check Body, and Butterfly Valve Body: Cast iron, ASTM A 126, Grade B.
   5. Air Release Valve Needle: Buna-N.
   6. Air and Vacuum Valve Seat:
      a. Sizes 4 Inch Through 12 Inch: Buna N.
      b. Sizes 14 Inch and Larger: Stainless steel ASTM A 240 with Buna N molded seal.
   7. Leverage Assembly: Delrin.

2.03 AIR AND VACUUM VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, APCO Number 140 Series.

B. Design:
   1. Minimum Performance Requirements:
      a. Air In-flow Through Valve: Not less than 24 standard cubic feet per second.
      b. Air Exhaust Through Valve: Not less than 14 standard cubic feet per second.
   2. Pressure Rating: Suitable for service under operating pressures equal to and less than 125 pounds per square inch guage.
   3. Inlet: Screwed, 3-inch size.

C. Materials:
   1. Body: Cast iron.
   2. Float: Stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with Section 15110.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Piping specialties including:
   1. Flexible rubber connections.
   2. Pipe saddles for ductile iron pipe.
   3. Tapping sleeves.
   4. Pressure gauges.

B. Related Sections:
   1. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

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

B. American National Standards Institute/American Water Works Association (ANSI/AWWA):

C. American Society for Testing and Materials (ASTM).

D. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Product Data:
   1. Manufacturer's certificate attesting successful performance of specified tests.
   2. Shop drawings detailing dimensions and materials. Provide weights for each size of ball type flexible expansion joint used on the project.
   3. Manufacturer's published installation instructions.
   4. Operation and maintenance manuals.
1.04 DELIVERY, STORAGE, AND HANDLING

A. Bellows Type Expansion Joints and Vibration Control Joints:
   1. Protect joints against damage during packing, shipping and installation, and also during pressure test.
   2. Lock expansion joints against movement until pressure tests are completed.
   3. Replace damaged expansion joints with new and undamaged expansion joints.

PART 2 PRODUCTS

2.01 FLEXIBLE RUBBER CONNECTIONS

A. Rubber Expansion Couplings:
   1. Manufacturers: One of the following or equal:
      a. PROCO Products, Inc., Series 240 HW.
   2. Provide flexible rubber connections with 3/8 inch thick neoprene rubber tube with full faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge. Cover to be neoprene rubber.
   3. Provide complete flexible rubber connections, including galvanized retaining rings and control rods. Number and type of flexible rubber connections are to be provided by the manufacturer. The number of control rods are to be per the Manufacturer’s recommendation but not less than three control rods per connection.

2.02 PIPE SADDLES FOR DUCTILE IRON PIPE

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

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

2.03 TAPPING SLEEVES

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

B. Materials:
   1. Tapping Sleeves: Steel construction.
   2. Bolts and Nuts: Type 304 stainless steel.
   5. Size of Tapped Boss: As indicated on the Drawings.
2.04 PRESSURE GAUGES

A. Design:
1. Provide dual-range, liquid filled gauges with ranges as indicated on the Drawings as pressure gauge Mark 1.
2. Size: As follows, unless otherwise indicated on the Drawings or specified:
   a. For 1-Inch Pipe and Larger: 4-1/2 inch diameter.
   b. For Smaller than 1-Inch Pipe: 2-1/2 inch diameter.
3. Provide gauges with Type 304 stainless steel, wetted parts phenolic cases back flanged aluminum cases with threaded ring, except for panel mounting, in which case provide gauge with front flanged aluminum case with threaded ring. Apply black epoxy coating to cases.
4. Provide case fitted with a rupture disc which shall relieve out the back of the case.
5. Window: Shatterproof glass or high temperature acrylic.
6. Provide gauges with Type 316 stainless steel socket and bellows or bourdon tube, depending on pressure range.
   a. Where the maximum pressure is less than or equal to 15 pounds per square inch, the gauge shall use bellows as the measuring element.
   b. Where the maximum pressure is greater than 15 pounds per square inch, the measuring element shall be a bourdon tube.
7. Socket Tips:
   a. Socket Tips for Bellows and Bourdon Tube: Type 316 Stainless steel.
   b. Size: 1/2 inch for 4-1/2 inch diameter gauges, 1/4 inch for 2-1/2 inch diameter gauges.
8. Pressure gauges, except gauges with diaphragm seals, shall have pulsation dampeners installed between the gauge and the shut-off valve.

B. Manufacturers:
1. Pressure Gauges: One of the following or equal:
   a. U.S. Gauge Division of Ametek, Inc., Solfrunt Gauges, Figure Number 1931T.
   b. Dresser Industries, Inc., Ashcroft Figure Number 1379.
2. Pulsation Dampeners: One of the following or equal:
   a. Dresser Industries, Inc., Ashcroft Figure Number 1106S.
   b. Operation and Maintenance Specialties, Charlotte, N.C., Ray Pressure Snubbers.

PART 3 EXECUTION

3.01 INSTALLATION

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

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

C. Pressure Gauges:
   1. Install pressure and compound gauges as indicated on the Drawings, in the Pressure Gauge Schedule, and as specified.
2. Install gauges as specified, and as recommended by the manufacturer in published instructions.

3.02 FIELD QUALITY CONTROL

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

END OF SECTION
SECTION 15121

PIPE COUPLINGS

PART 1  GENERAL

1.01 SUMMARY

A. Section includes:
   2. Bolted, split-sleeve flange adapter coupling.
   3. Dismantling joints.
   5. Flanged coupling adapters.
   6. Flexible couplings.
   7. Restrained flange coupling adapters.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 09960 - High-Performance Coatings.
      b. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):

D. ASTM International (ASTM):
3. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

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

1.03 SUBMITTALS

A. Shop drawings, detailing dimensions, and materials.

B. Piping layout drawings: Coordinate preparation of required piping layout drawings such that coupling center sleeve sizes are clearly indicated on the Drawings.

C. Manufacturer's published installation instructions.

PART 2 PRODUCTS

2.01 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
1. Manufacturers: One of the following or equal:
2. Materials:
   a. Flanged spool:
      1) C207 Schedule 40 steel pipe in accordance with ASTM A 53 for sizes 3 inches to 12 inches.
      2) Steel for pipe in accordance with ASTM A 36 for sizes 14 inches to 72 inches.
   b. End ring and body:
      1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A 536.
2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A 36 or A 53.

c. Follower ring: Ductile iron in accordance with ASTM A 536 or steel in accordance with ASTM A 36 or A 576.

d. Bolts and hex nuts:
   1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
   2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.

e. Tie rods: High tensile steel in accordance with ASTM A 193 Grade B7.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.

4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.
   a. As specified in Section 09960

B. Flanged coupling adapters: 12-inch size and smaller.
   1. Manufacturers: One of the following or equal:
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A 536.
      b. Follower ring: Ductile iron in accordance with ASTM A 536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

C. Flanged coupling adapters: Greater than 12-inch size:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Industries, Inc., Style FC400.
   2. Materials:
      a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

D. Flexible couplings:
1. Manufacturers: One of the following or equal:
2. Materials:
   a. Center rings: Ductile iron in accordance with ASTM A 536.
   b. Follower rings: Ductile iron in accordance with ASTM A 536.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F 593.
3. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Sleeve Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch and smaller</td>
<td>Manufacturer’s standard</td>
</tr>
<tr>
<td>4 inch through 8 inch</td>
<td>7 inches</td>
</tr>
<tr>
<td>10 inch through 14 inch</td>
<td>12 inches</td>
</tr>
<tr>
<td>Greater than 16 inch</td>
<td>Use steel flexible coupling per Pipe Couplings for Steel Piping</td>
</tr>
</tbody>
</table>

E. Restrained flange coupling adapter:
1. Manufacturers: One of the following or equal:
   a. Romac Industries, Inc., Style RFCA.
   b. Star Pipe Products, 3200 StarFlange.
2. Materials:
   a. Flange and flanged body: Ductile iron in accordance with ASTM A 536.
   b. Follower ring: Lug type restraint system.
      1) Follower ring: Ductile iron in accordance with ASTM A 536.
      2) Restraining lugs: Ductile iron in accordance with ASTM A 536.
         a) Designed to contact the pipe and apply forces evenly.
      3) Restraining bolts:
         a) Ductile iron in accordance with ASTM A 536.
         b) Bolt heads shall be designed to twist off when the proper torque has been applied.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

F. Grooved joint couplings:
   1. Manufacturers:
      a. Victaulic Company, Series 31 or equal.
   2. Materials:
      a. Housings: Ductile iron in accordance with ASTM A 536.
      b. Gasket:
         1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D 2000.
         2) Neoprene or BUNA-N.
      c. Bolts and nuts: Electroplated steel in accordance with ASTM A 449.
      d. Coating: As specified in Section 09960
   3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
   4. For connection to IPS steel pipe sizes, Victaulic Style 307.

2.02 PIPE COUPLINGS FOR STEEL PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
   2. Materials:
      a. Flanged spool:
         1) C207 Schedule 40 pipe in accordance with ASTM A 53 for sizes 3 inches to 12 inches.
         2) Steel for pipe in accordance with ASTM A 36 or A 53 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A 536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A 36.
      c. Follower ring: Ductile iron in accordance with ASTM A 536 or steel in accordance with ASTM A 36 or A 576.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
      e. Tie rods: High tensile steel in accordance with ASTM A 193 grade B7.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.

B. Flanged coupling adapters:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
b. Romac Industries, Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).


2. Materials:
   a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   c. Bolts and hex nuts:
      1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.

4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      c. Romac Industries, Inc., Style 511 or Style 400.
   2. Materials:
      a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   3. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.
   4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Sleeve Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inch and smaller</td>
<td>Manufacturer’s standard</td>
</tr>
<tr>
<td>3 inch through 6 inch</td>
<td>7 inch</td>
</tr>
<tr>
<td>8 inch through 14 inch</td>
<td>7 inch</td>
</tr>
<tr>
<td>Greater than 14 inches</td>
<td>10 inch</td>
</tr>
</tbody>
</table>

D. Restrained flange coupling adapters:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style RFCA.
      b. Star Pipe Products, 3200 StarFlange.
   2. Materials:
      a. Flange and flanged body: Ductile iron in accordance with ASTM A 536.
b. Follower ring: Lug type restraint system.
   1) Follower ring: Ductile iron in accordance with ASTM A 536.
   2) Restraining lugs: Ductile iron in accordance with ASTM A 536.
      a) Designed to contact the pipe and apply forces evenly.
   3) Restraining bolts: Ductile iron in accordance with ASTM A 536. Bolt
      heads shall be designed to twist off when the proper torque has been
      applied.

c. Bolts and hex nuts:
   1) Aboveground: High-strength, low-alloy steel in accordance with
      AWWA C111.
   2) Buried and underwater: Type 316 stainless steel bolts in accordance
      with ASTM F 593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207
   compatible with ANSI Class 125 and 150 bolt circles.

4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in
   accordance with NSF 61.

E. Grooved joint couplings:
   1. Model numbers from one manufacturer are shown to indicate type only.
      Equivalent products of other manufacturers may be submitted for approval.
   2. Coating: As specified in Section 09960
   3. Sizes through 12 inch:
      a. Rigid type:
         1) housings shall be cast with offsetting angle-pattern bolt pads to
            provide rigidity and system support and hanging in accordance with
            ASME B31.1 and B31.9.
         2) 2 inch through 6 inch: Installation-ready, for direct stab installation
            without field disassembly, with grade EHP gasket rated to plus 250
            degrees Fahrenheit.
         3) Manufacturer: One of the following or equal:
            a) Victaulic Style 107.
            b) Victaulic Zero-Flex Style 07.
      b. Flexible type:
         1) For use in locations where vibration attenuation and stress relief are
            required.
         2) Three flexible couplings may be used in lieu of a flexible connector.
         3) The couplings shall be placed in close proximity to the source of the
            vibration.
         4) Manufacturer: The following or equal:
            a) Victaulic Style 77.
      c. Flange adapter:
         1) Flat face, ductile iron housings with elastomer pressure responsive
            gasket, for direct connection to ANSI Class 125 or 150 flanged
            components.
         2) Manufacturer: The following or equal:
            a) Victaulic Style 741.

F. Bolted, split-sleeve couplings:
   1. Provide bolted, split-sleeve couplings where indicated on the Drawings or as
      an alternative to flexible couplings when approved by the ENGINEER for each
      individual case.
   2. Split-sleeve type pipe coupling with double arch cross section.
a. Coupling shall be designed to close around the pipe ends, confining the gaskets beneath the arches of the sleeve.
b. A watertight, axial seal is created by tightening the bolts to pull the coupling against the outside wall of the pipe.

3. Coatings:
   a. Couplings shall be epoxy-coated on the inner diameter and outer diameter prior to delivery.
   b. Buried couplings shall receive additional protection against corrosion that matches the pipe as specified in Section 09960.

4. Couplings: Wall thickness that is adequate for the test pressure as specified in the Piping Schedule in Section 15052.
   a. Provide split-sleeve type coupling in an “expansion x expansion” configuration where indicated on the Drawings.
   b. Where restrained pipe joints are required or are indicated on the Drawings, provide split-sleeve type coupling in a “fixed x fixed” configuration.
      1) Coordinate with coupling manufacturer and pipe supplier to provide restraint rings on pipe.
      2) Coupling manufacturer to supply the restraint rings.
   c. Where axial pipe expansion must be accommodated or where they are indicated on the Drawings, provide split-sleeve type coupling in a “fixed x expansion” configuration.
      1) Coordinate with coupling manufacturer and pipe supplier to provide restraint ring on fixed side of coupling.
      2) Coupling manufacturer to supply the restraint rings.
   d. Axial restraint and angular deflection:
      1) Where axial restraint is required to resist pipe thrust and angular deflection is required to provide flexibility in the piping or where they are indicated on the Drawings, provide split-sleeve type coupling in a “fixed x fixed modified” configuration.
      2) Install coupling with manufacturer’s recommended-gap between ends of piping with the shoulders of coupling bearing on the inner restraint rings that are welded to the piping at both ends of coupling.
      3) Coupling shall be designed for an angular deflection of not less than the angular deflection indicated in the following table unless a larger angular deflection is indicated on the Drawings.

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Allowable Angular Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 inch and smaller</td>
<td>3 degrees</td>
</tr>
<tr>
<td>20 inch</td>
<td>2.5 degrees</td>
</tr>
<tr>
<td>24 inch</td>
<td>2 degrees</td>
</tr>
<tr>
<td>30 inch</td>
<td>1.75 degrees</td>
</tr>
<tr>
<td>36 inch</td>
<td>1.5 degrees</td>
</tr>
<tr>
<td>42 inch</td>
<td>1.25 degrees</td>
</tr>
<tr>
<td>48 and 54 inch</td>
<td>1 degree</td>
</tr>
<tr>
<td>60 inch</td>
<td>0.875 degrees</td>
</tr>
<tr>
<td>66 and 72 inch</td>
<td>0.75 degrees</td>
</tr>
</tbody>
</table>

5. Restraint rings:
   a. Provide where required to create a restrained joint.
   b. Coordinate with piping manufacturer.
c. Shop fabricate pipe with restraint rings that engage the interior edge of the coupling shoulder.
   1) Weld for restraint ring: Suitable for test pressures indicated in the Piping Schedule as specified in Section 15052.

6. Gaskets: The sealing members are comprised of 2 O-ring gaskets. Internal pressure shall not be required to affect the seal. For water service, the gasket supplied shall be Isoprene or Buna-N in accordance with ASTM D 2000 for design pressure within temperature range of minus 20 to 180 degrees Fahrenheit.
   a. Elastomers shall have properties in accordance with ASTM D 2000.

7. Manufacturers: One of the following or equal:
   a. “Expansion x expansion” configuration:
      1) Victaulic, Depend-O-Lok, E x E, Type 2 Coupling.
   b. “Fixed x expansion” configuration:
      1) Victaulic, Depend-O-Lok, F x E, Type 2 Coupling.
   c. “Fixed x fixed” configuration:
      1) Victaulic, Depend-O-Lok, F x F, Type 2 Coupling.
   d. “Fixed x fixed modified” configuration:
      1) Victaulic, Depend-O-Lok, F x F, Type 2 Modified Restrained Coupling.

8. Materials:
   a. Couplings: Steel in accordance with ASTM A 36.
   b. Bolts and nuts: In accordance with ASTM A 325 and ASTM A 563.

9. Pipe preparation:
   a. Pipe ends shall be smooth for expansion or contraction requirements.
   b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
   c. The coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe by the pipe manufacturer in accordance with the coupling manufacturer’s requirements.
   d. Follow coupling manufacturer’s recommendation for size and amount of welding required to attach the restraint rings to the pipe.

2.03 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible couplings:
   1. Manufacturers: One of the following or equal:

B. Grooved joint couplings:
   1. Manufacturers: One of the following or equal
      a. Victaulic Company.
   2. Materials:
      a. Housings:
         1) Ductile iron in accordance with ASTM A 536.
         2) Stainless steel in accordance with ASTM A 351.
      c. Bolts and nuts:
         1) Electroplated steel in accordance with ASTM A 449.
         2) Stainless steel in accordance with ASTM F 593.
3. Rigid type:
   a. Victaulic Style 89 and W89 (ductile iron housings)
   b. Victaulic Style 489 (stainless steel housings)
4. Flexible type: Victaulic Style 77S.

2.04 GASKETS FOR FLEXIBLE COUPLINGS AND FLANGED COUPLING ADAPTERS

A. Provide gasket materials for piping applications as follows:
   1. Low-pressure and high-pressure air, steam, hot water: EPDM.
   2. All other piping applications: Neoprene rubber or Buna-N.

2.05 EXTERIOR COATINGS FOR UNDERGROUND AND SUBMERGED APPLICATIONS

A. Manufacturers: One of the following or equal:

B. Thickness: Minimum 0.040 inch.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
   1. Install flexible coupling with pipe gap located in middle of center sleeve.
   2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

<table>
<thead>
<tr>
<th>Center Ring Length</th>
<th>Gap Dimension and Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch through 6 inch</td>
<td>3/8 inch</td>
</tr>
<tr>
<td>7 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>10 inch and greater</td>
<td>7/8 inch</td>
</tr>
</tbody>
</table>

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
   1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052.

E. Grooved joint couplings:
   1. Grooved joints shall be installed in accordance with the manufacturer’s latest published installation instructions.
2. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
3. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.
4. The grooved coupling manufacturer’s factory trained representative shall provide on-site training for CONTRACTOR’s field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review CONTRACTOR is following best recommended practices in grooved product installation. (A distributor’s representative is not considered qualified to conduct the training or jobsite visit(s).)

F. Bolted, split-sleeve couplings:
1. Inspect each coupling to insure that there are no damaged portions of the coupling.
   a. Pay particular attention to the sealing pad/sealing plate area.
   b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all time.
2. Wrenches used shall be of a size and type recommended by the manufacturer.
   a. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
   b. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
3. No joint shall be misfit any amount that would be detrimental to the strength and water tightness of the finished joint.
4. On the fixed ends of bolted, split-sleeve couplings, the shoulders shall bear on the restraint rings all around with no gap.
5. Ends of piping where coupler are installed shall be smooth and free of defects.
   a. Remove weld splatter and grind smooth.
   b. Grind pipe seam welds flush with pipe wall and smooth.

3.02 FIELD QUALITY CONTROL

A. Bolted, split-sleeve coupling:
   1. Manufacturer’s representative shall be on site during installation of all couplings.

END OF SECTION
SECTION 15230
PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

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

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is
      as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating
      the Work of subcontractors, suppliers, and other individuals or entities
      performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section.
      This list of Related Sections is provided for convenience only and is not
      intended to excuse or otherwise diminish the duty of the CONTRACTOR
      to see that the completed Work complies accurately with the Contract
      Documents.
      a. Section 15052 - Common Work Results for General Piping.
      b. Section 15956- Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

B. ASTM International (ASTM):
   1. D 1248 - Standard Specification for Polyethylene Plastics Extrusion
      Materials For Wire and Cable.
      Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
      Pipe, Schedules 40, 80 and 120.
      Pipe.
      Characteristics of Plastic Pipe by Parallel-Plate Loading.
      Pipe Fittings, Schedule 40.
      Pipe Fittings, Schedule 80.
   8. D 2513 - Standard Specification for Thermoplastic Gas Pressure Pipe,
      Tubing and Fittings.
       Drain, Waste, and Vent Pipe and Fittings.

C. American Water Works Association (AWWA): 
1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches (100 mm Through 300 mm), for Water Transmission Distribution. 

D. NSF International (NSF). 

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

1.03 ABBREVIATIONS 

B. CPVC: Chlorinated polyvinyl chloride. 
C. DR: Dimension ratio. 
D. DWV: Drain, waste, and vent. 
E. ID: Inside diameter of piping or tubing. 
F. NPS: Nominal pipe size followed by the size designation.
G. **NS:** Nominal SIZE of piping or tubing.

H. **PE:** Polyethylene.

I. **PP:** Polypropylene.

J. **PVC:** Polyvinyl chloride.

K. **SDR:** Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

### 1.04 SUBMITTALS

A. **Product data:** Describe materials, pipe, fittings, gaskets, and solvent cement.

B. **Manufacturer’s Published Installation Instructions.**

C. **Certificates:**
   1. Copies of solvent cement manufacturer’s report and certification in accordance with ASTM D 2564 for PVC piping, and ASTM F 493 for CPVC piping.

### 1.05 QUALITY ASSURANCE

A. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

### PART 2 PRODUCTS

#### 2.01 MATERIALS

A. **Extruding and molding material:** Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. **Fittings:** Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. **Unions 2-1/2 inches and smaller:** Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft EPDM gasket.
2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D 1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D 1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D 2466 or ASTM D 2467.
      c. DWV fittings: In accordance with ASTM D 2665.
   3. Solvent cement: In accordance with ASTM D 2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp Type P70.
         2) Cement: IPS Corp Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC PIPING, CLASS TYPE

A. PVC pipe, Class Type: In accordance with ASTM D 2241:
   1. Thermoplastic pipe materials designation code: PVC 1120, 1220, or 2120.
   2. PVC compound: Class 12454-B in accordance with ASTM D 1784.
   3. Standard dimension ratio: SDR as called out on the drawings.

B. Fittings: Ductile iron with transition gasket sized to accommodate the outside pipe diameter.

2.04 CPVC PIPING

A. Materials:
   1. CPVC pipe: Schedule 40 or Schedule 80, as specified, in accordance with ASTM F 441 and Appendix, CPVC 4120:
      a. Pipe: Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D 1784.
      b. Manufacturers: One of the following or equal:
         1) Charlotte Pipe and Foundry Company.
         2) Eslon Thermoplastics, Inc.
         3) Harvel Plastics, Inc.
   2. Fittings: In accordance with ASTM F 438 or ASTM F 439 for pressure fittings, as appropriate to the service and pressure requirement:
      a. Fittings: Supplied by the pipe manufacturer.
      b. Manufacturers: One of the following or equal:
         1) Colonial Engineering.
         2) Eslon Thermoplastics, Inc.
         3) Chemtrol.
         4) Spears Manufacturing Company; or equal.
   3. Solvent cement: In accordance with ASTM F 493:
      a. For CPVC pipe in chemical service, utilize IPS Corp Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.
2.05 PP PIPING

A. Materials:
   1. Pipe: Schedule 40 dimensions, extruded from Type I-19509 material in accordance with ASTM D 4101.
   2. Fittings: Molded from the same material and same laying length in accordance with ASME B 16.12:
      a. Fittings: Manufactured by pipe manufacturer.

2.06 PE TUBING AND FITTINGS

A. Materials:
   1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
      a. Plastic tubing ID as follows:
         1) For NS 1/4 inch, ID of 0.170 inch.
         2) For NS 5/16 inch, ID of 0.187 inch.
         3) For NS 3/8 inch, ID of 0.251 inch.
         4) For NS of 1/2 inch, an ID of 0.375 inch.
   2. Fittings: Compression fittings, Dekoron E-Z; or equal.
   3. Protective sheath:
      a. Manufacturers: One of the following or equal:
         1) Dekoron, "Poly-Cor."
         2) Parker Hannifin Corp./Fluidconnector Products, Parflex Division, Multitube.
   4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

2.07 POLYETHYLENE PIPING FOR UNDERGROUND GAS DISTRIBUTION

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

B. Manufactured in accordance with ASTM D 2513 using a compound in accordance with ASTM D 1248, PE 2306/2406:
   1. SDR: Maximum of 11.

C. Fittings: In accordance with ASTM D 2513 for socked fusion joints, and ASTM D 3261 for butt fusion joints.

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

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

B. Manufacturers: One of the following or equal:
   1. DuPont, Sclairpipe.
   2. Polaris, Duratuff; or equal.
C. Pipe, fittings, and adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

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

2.09 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D 1785.

B. PVC piping, Class Type:
   1. Test pipe to withstand, without failure, 600 pounds per square inch gauge, hydrostatic pressure for a minimum of 5 seconds.
   2. Test integral bell with the pipe.

C. PVC gravity sewer piping:
   1. Mark pipe and fittings in accordance with ASTM D 3034. Also mark the production control code on pipe and fittings.

D. CPVC piping:
   1. Mark pipe and fittings in accordance with ASTM F 441.

E. PP piping:
   1. Test samples and testing: Cut test samples of pipe, 6 inches long, from full length sections and test by the method outlined in accordance with ASTM D 2412:
      a. Deflect pipe at least 35 percent without failure. Stiffness at 5 percent deflection equals or exceeds 55 pounds per square inch after the test samples have been immersed in a 5 percent solution by weight of sulfuric acid and n-Heptain for a period of 24 hours prior to testing.
      b. Failure is defined as rupture of the pipe wall.
      c. Stiffness factor may be computed by the method outlined in accordance with ASTM D 2412 or by dividing the load in pounds per linear inch by the deflection in inches and 5 percent deflection.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F 645, or manufacturer’s published instructions for installation of piping, as applicable to the particular type of piping.
2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping. Schedule Type:
1. Solvent weld joints in accordance with ASTM D 2855:
   a. For PVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.
2. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC piping, Class Type:
1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

D. Installation of PVC gravity sewer piping:
1. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
2. Install pipe and fittings not later than 4 months after their manufacture.
3. Provide for contraction and expansion at joints with a gasket ring.
4. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
5. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
6. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
   a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
   b. Grout around the manhole gasket and seal the opening.

E. Installation of CPVC piping:
1. Clean dirt and moisture from pipe and fittings.
2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file. Remove burrs.
3. Use solvent cement and primer formulated for CPVC:
   a. For CPVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.
4. Use primer on pressure and non-pressure joints.
5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

F. Installation of PP piping:
1. Install piping in accordance with manufacturer's published instructions.

G. Installation of polyethylene (PE) tubing and fittings:
1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
2. Bundle tubing in groups of parallel tubes within protective sheath.
3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician’s tape.
4. Grade tubing connected to meters in one direction.

H. Installation of PE piping for underground gas distribution:
   1. Socket fuse joints for piping equal or less than NPS 2.
   2. Butt fuse joints for piping larger than NPS 2.
   3. Install piping in accordance with requirements of the gas utility company and with manufacturer’s published instructions.

I. Installation of PE piping for drain, waste, and vent:
   1. Install piping as recommended in manufacturer's published instructions.

3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
   1. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 15956.
   2. Pressure test with maximum leakage allowance: Perform test after backfilling:
      a. Pressure: 125 pounds per square inch, gauge.
      b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

<table>
<thead>
<tr>
<th>NPS, Inches</th>
<th>1-1/2</th>
<th>2</th>
<th>2-1/2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leakage</td>
<td>0.41</td>
<td>0.52</td>
<td>0.63</td>
<td>0.76</td>
<td>0.98</td>
<td>1.45</td>
<td>1.88</td>
<td>2.35</td>
<td>2.80</td>
</tr>
</tbody>
</table>

B. Leakage test for HDPE piping:
   1. Pressure test with maximum leakage allowance: Perform test prior to backfilling (cover pipe at intervals and/or curves if necessary to hold pipe in place during testing):
      a. Pressure: As specified in Section 15052 or 125 pounds per square inch, gauge.
      b. Test with water as test medium.
      c. Remove all free air from test section and raise pressure at steady rate to test pressure.
      d. Apply and allow initial test pressure to stand without makeup pressure for 3 hours to allow for diametric expansion or pipe stretching to stabilize.
      e. After stabilization period, return to test pressure and hold for 3 hours.
      f. Amount of make up water allowable for expansion during pressure test in accordance with PPI Technical Report TR 31-88.
      g. No visual leaks or pressure drops allowed during final test period.

END OF SECTION
SECTION 15251
DUCTILE IRON AWWA C151 PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02318 - Trenching.
      b. Section 09960 - Coatings.
      c. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

B. American Water Works Association (AWWA):
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

C. American Welding Society (AWS):

D. ASTM International (ASTM):

E. Ductile Iron Pipe Research Association (DIPRA):

F. NACE International (NACE):
   1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
   1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. The pipe alignment from Station 10+50 through 305+00 is designed as welded steel pipe or ductile iron pipe. CONTRACTOR shall provide fittings, bends, and off-sets as required to maintain the alignment as shown on the drawings.
   1. If ductile iron is used for this pipeline, CONTRACTOR shall provide details for connection to steel pipelines at the pump station and standpipe. Connection shall be flanged and cathodically isolated using flange isolation kits.

B. Thrust restraint system design:
   1. Design restrained joint thrust restraint system.
   2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 15052 and the following additional criteria:
      a. **Design pressure:** Test pressure.
      b. **Laying condition:** Type 4 in accordance with AWWA C150 for design purposes.
      c. **Soil designation:** Clay 2 as defined by DIPRA.
      d. **Unit friction resistance:** Based upon polyethylene encasement of pipe.
      e. **Safety factor:** 1.5 (for thrust restraint calculations only).
      f. Minimum required restrained length shall be as indicated on Drawings.

1.04 SUBMITTALS

A. Product data: Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.
B. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, connections to structures, and thrust restraint system layouts.
   2. Thrust restraint systems: Calculations and layout for restrained joint thrust restraint systems.

C. Design calculations:
   1. Calculations for thrust restraint system design.
   2. Minimum required restrained lengths provided are only a guideline and cannot be used unless calculations from the manufacturer show required lengths less than these values. If required lengths prove to be more than the provided lengths, Contractor shall restrain pipe per manufacturer’s calculations.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Welded on outlets: The pipe manufacturer shall have a minimum of 5 years experience in the fabrication and testing of outlets of similar size and configuration similar to those used on the Project.

B. Pre-installation meeting:
   1. Arrange for Coating Manufacturer’s Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

C. Warranty:
   1. The CONTRACTOR shall warrant, and shall obtain from the manufacturer its warranty, that the pipe conforms to these specifications and will be free from defects in materials and workmanship for a period of 5 years from the date of Substantial Completion of this Contract. Said manufacturer's warranty shall be in a form acceptable to, and for the benefit of, the OWNER, and shall be submitted as a condition of final payment.
   2. The CONTRACTOR shall repair or replace, at the sole option of, and at no cost to the OWNER and their representatives, any work found to be defective within said warranty period. Such repair or replacement shall include the cost of removal and reinstallation, inspection, and acceptance testing.
   3. The CONTRACTOR shall also warrant to the OWNER that the materials used on this Contract, where covered by patents or license agreements, are furnished in accordance with such agreements and that the prices included herein cover all applicable royalties and fees in accordance with such license agreements.
   4. The CONTRACTOR shall defend, indemnify, and hold the OWNER and their representatives harmless from and against any and all costs, loss, damage, or expense arising out of, or in any way connected with any claim or infringement or patent, trademark, or violation of license agreement.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

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

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

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

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

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Typical type:
      a. In accordance with AWWA C150 and AWWA C151.
      b. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052.

B. Joints:
   1. Gaskets: EPDM
   3. Restrained Joints: Integrially restrained push-on joints:
      a. Application:
         1) Where restrained push-on are required to provide adequate restraint, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations and per requirements on contract drawing P-25.
         2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
      b. Design:
         1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
         2) Suitable for the following working pressures:
            a) For 4 through 24-inch pipe: 350 pounds per square inch gauge.
            b) For 30 through 54-inch pipe: 150 pounds per square inch gauge.
      c. Manufacturers: One of the following or equal:
         1) United States Pipe and Foundry Company, TR Flex.
         3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
         4) Griffin Pipe Products Co., Snap-Lok.
d. Limit buried joints to half the manufacturer’s published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

d. Limit buried joints to a maximum 2 degree deflection at each joint.

4. Megalug joints are not permissible unless by direction of Engineer.

5. **Flanged joints:**
   a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
      1) Ductile iron.
      2) Long hub, threaded, and specially designed for ductile iron pipe.
      1) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
   b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
   c. Cap screw or stud bolt holes: Tapped.
   d. Bolts and nuts: As specified in Section 15052.
   e. Gaskets: EPDM

C. **Fittings:**
   1. Ductile iron in accordance with AWWA C110 or AWWA C153.
   2. Joint type: Refer to piping schedule in spec 15052 for joint type.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. **Pipe linings and coatings:**
   1. Cement-mortar lining:
      a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
      b. Minimum lining thickness: Standard in accordance with AWWA C104.
      c. Type of cement: Type II.
   2. Asphaltic seal coat:
      a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating. Apply in accordance with AWWA C151.

E. **Piping Outlets:**
   1. Provide welded-on outlets for outlets 4 inches and larger.
   2. Fabrication:
      a. Welded-on outlets shall be fabricated by the pipe manufacturer at the facility where the pipe is produced.
      b. Application is limited to branch outlets having a nominal diameter not greater than 70 percent of the nominal diameter of the main line pipe or 36 inches.
      c. Parent pipe and branch outlet candidate pipe shall be centrifugally cast ductile iron pipe designed in accordance with AWWA C150 and manufactured in accordance with AWWA C151. Minimum classes for parent and outlet pipe:
         1) Sizes 4- through 54-inch: Special Thickness Class 53.
         2) Sizes 60- through 64-inch: Pressure Class 350.
      d. Electrodes for reinforcing welds:
         Manufacturers: One of the following or equal:
         NCO Alloys, Ni-Rod 55-0 flux cored wire.
INCO Alloys, Ni-Rod 55 welding electrode.
Stoody Castweld, Ni 55-0 flux cored wire.
INCO Alloys, Ni-Rod 44 Filler Metal.
Carbon steel electrodes are not acceptable.

3. Pressure rating:
   a. Welded-on outlets 4- through 30-inch: Rated for a working pressure of 250 pounds per square inch.
   b. Welded-on outlets 36-inch and larger: Rated for 200 pounds per square inch.
   c. Welded-on outlets of all diameters and configurations: Have a minimum safety factor of 2.0 based on proof of design hydrostatic test results. The CONTRACTOR shall, at the request of ENGINEER, provide the manufacturer’s representative proof test data confirming the design, hydrostatic test results, and safety factors.

4. Source quality control:
   a. Branch outlets shall be subjected to an air pressure test of at least 15 pounds per square inch. Air leakage is not acceptable. Any leakage shall be detected by applying an appropriate foaming solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles.
   b. Hydrostatic testing to 500 pounds per square inch on each branch outlet can be used in lieu of air testing.
   c. Any weldment that shows any signs of leakage shall be repaired and retested in accordance with the manufacturer’s written procedures.
   d. Pipe manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records in accordance with AWS D11.2.
   e. Pipe manufacturer shall maintain appropriate welding procedure specification, procedure qualification, and welder performance qualification test records as well as appropriate air-test logs documenting air-leakage tests on all welded-on outlet pipes furnished to the Project.

2.02 POLYETHYLENE ENCASEMENT

A. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 15 mils each in accordance with AWWA C105.

A. CONTRACTOR shall wrap all buried ductile iron piping with 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils each in accordance with AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 15052.
2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318.

B. Polyethylene encasement:
   1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose polyethylene wrap in accordance with AWWA C105.
   2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
   3. At wall penetrations, extend encasement to the wall and neatly terminate.
   4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
   5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.
   6. Repair tears and make joints with 2 layers of plastic tape.
   7. All work shall be inspected prior to backfilling of pipe and associated items.

C. Joints:
   1. Install types of joints as specified in the piping schedule provided in Section 15052.
   2. Cathodic Protection: Monitor steel pipe for external corrosion as specified in Section 13112. Joints are to be bonded as shown on the drawings and specified in specification section 13112.
   3. Mechanical joints are not acceptable in above ground applications.
   4. Field closure for restrained push-on pipe:
      a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.

D. Tapping ductile iron pipe:
   1. Direct tapping of ductile iron pipe may not be performed.

3.02 FIELD QUALITY CONTROL

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

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
   1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

END OF SECTION
SECTION 15252A

STEEL PIPING

PART 1  GENERAL

1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, pipe lining and coating, and fabricated steel piping fittings and specials.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 09960 - Coatings.
      b. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

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

B. American Society of Mechanical Engineers (ASME):
   3. B16.5 - Pipe Flanges and Flanged Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   4. C206 - Field Welding of Steel Water Pipe.

D. ASTM International (ASTM):

E. National International (NACE):
1. RP0274-74 - Standard Recommended Practice.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
1. Design criteria for pipe and pipe fittings: In accordance with AWWA Manual M11 with the following modifications:
   a. Wall thickness: As designed by CONTRACTOR per requirements in this specification; minimum wall thickness is 0.25 inch for pipe 12 inches diameter and greater.
   b. Inside diameter of unlined pipe: Nominal.
   c. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.
   d. Deflection of underground pipe inside diameter: Maximum 1.5 percent under trench load of H-20 live load in accordance with AASHTO specifications.
   e. Working stress of steel: Maximum 50 percent of yield stress.
1.04 SUBMITTALS

A. Shop drawings: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; listing of proposed services and locations for use of grooved joint type piping; tabulated layout schedules for cement-mortar lined and coated steel pipe.

B. Product data: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; grooved joint piping fittings, gaskets, couplings, grooving of pipe and fittings, and pipe lining and coating.

C. Certificates of Compliance: Cement-mortar lined and coated steel pipe.

D. Design calculations: Wall thicknesses for external loading, special loading, and internal pressure.

E. Mill certificates.

F. Test reports: Rubber gaskets.

1.05 QUALITY ASSURANCE

A. Applicable standards:
   1. Cement-mortar lined and coated steel pipe shall conform to the following standards, as complemented and modified in this Section:
      b. Cement-mortar lining and coating: AWWA C205.
      c. Fittings and specials: AWWA C208.
      d. Reinforcement of fittings and specials: AWWA M 11.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel pipe:
   1. Type, pipe 6 inches and smaller: ASTM A 53, black or galvanized, seamless or straight seam electric resistance welded. Minimum Schedule 40.
   2. Type, from 6 to 12 inches: ASTM A 53, black or galvanized pipe, seamless or straight seam electric resistance welded. Minimum Schedule 20.
   3. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as specified.

B. Steel pipe fittings:
   1. Screwed fittings:
      a. Malleable iron: ASME B16.3, 150 pounds; galvanized in accordance with ASTM A 153 where used with galvanized pipe.
      b. Cast iron drainage: ASME B16.12, galvanized in accordance with ASTM A 153 where used with galvanized pipe.
   2. Flanged fittings:
      a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A 153 where used with galvanized pipe.
b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A 153 where used with galvanized pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.

c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.

d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.

e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A 153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.

f. Weld flanges to pipe or fittings before applying lining.

g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.

h. Flange bolts: As specified in Section 15052.

i. Gaskets: As specified in Section 15052.

3. Welding fittings:

a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.

b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of the CONTRACTOR, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.

c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWAC208 and as supplemented by AWWA Manual M 11. Welding of these made-up fittings shall be in accordance with AWWA C206.

1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA Manual M 11.

2) Bends may be welded to adjacent pipe sections.

a) Bends shall be manufactured of the following number of pieces:

   (1) Bends from 0 to 30 degrees angle, 2 pieces.

   (2) Bends from 30 to 45 degrees angle, 3 pieces.

   (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.

   (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.

C. Steel pipe lining and coating:

1. General:

a. Except where otherwise specified in the Specifications, lining and coating for steel pipe shall be as specified.

b. Pipe coating:

   1) Except as otherwise specified, provide underground steel piping with one of the coatings specified.

   2) Extend pipe coating for underground piping 6 inches above finish grade or finish floor, and neatly terminate.

   3) Field paint aboveground steel pipe as specified in Execution of this Section.

2. Cement-mortar lining and coating:

a. Lining:
1) Shop apply cement-mortar lining for steel pipe, interior, in accordance with AWWA C205; or, at the option of CONTRACTOR, field apply with a pipe lining machine.

b. Coating:
1) Cement-mortar coating for steel pipe exterior: In accordance with AWWA C205, modified as follows:
   a) Portland cement: ASTM C 150, Type II, low alkali.
   b) Sand: AWWA C205 except that the total percentage of deleterious material shall not exceed 3 percent.

3. Joint wrap:
a. Polyken 932-50, white Hi-Tack Joint Wrap tape.
b. Tapecoat Company, Joint Tape.

D. Fabricated steel piping fittings and specials:
1. General: Specified herein are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.

2. Design:
a. CONTRACTOR shall design and detail fittings and specials.
   1) Design: In accordance with the recommended procedures in AWWA Manual M 11, as complemented and modified in this Section.
   3) Design reinforcing for fittings and specials for the specified test pressure.
   4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
   5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.

b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
   1) The thickness designed in accordance with the design methods specified in the preceding paragraph “Fabricated Steel Piping Fittings and Specials.”
   2) The following thicknesses:
      a) For pipes smaller than 24 inches in diameter: Minimum 1/4 inch.

c. Elbows shall be of the number of pieces specified under paragraph Steel Pipe Fittings, “Welding and Fittings”, and thickness of material shall conform to thickness of pipe or manifold shells specified.

d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.

b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.

c. Fabricate fittings and specials to allow field assembly without cutting or special work.

d. Where specified in the Piping Schedule in Section 15052, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205.
e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
   1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.

4. Dished heads:
   a. Dished heads on 24 inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads.
      1) Larger heads may be seamed.
   b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
   c. Skirt face length: Not less than 3 inches.
   d. Design heads in accordance with recommended practice in AWWA M 11, Steel Pipe Manual.

5. Testing: No shop testing will be required for manifolds or piping connected thereto.

E. Steel pipe, cement-mortar lined and coated:
   1. General:
      a. Applicable standards: Cement-mortar lined and coated steel pipe shall conform to the standards specified in General of this Section.
      b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
         1) Name or trademark of the manufacturer.
         2) Date of manufacture of the item.
         3) Internal diameter in inches.
         4) Number of the item, sequential from initial to end station.
      c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.
   
   2. Design:
      a. Pipe and fittings shall be designed by CONTRACTOR.
      b. Design: In accordance with the recommended procedures in AWWA Manual M 11, as complemented and modified in this Section.
      c. Thicknesses of Pipe, Fittings and Specials Shall Be the Thicker Of:
         1) The thickness designed in accordance with the design methods specified in the preceding subparagraph below.
         2) The following thicknesses:
            a) For pipes less than 24 inches in nominal diameter, not less than 1/4 inch.
      d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
      e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates.
         1) Break longitudinal seams at the girth seams.
f. Calculate earth loads using the following formula:

\[ W = 140 \times H \times B \]

wherein the various terms shall have the following meaning:

- \( W \): Earth load, pounds per linear foot of pipe.
- \( H \): Height of fill over the pipe, feet.
- \( B \): Outside diameter of the pipe, feet.
- \( \times \): Mathematical symbol for multiplication.

g. Add AASHTO's H-20 loading to earth loads.

h. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 1.5 percent of the diameter.

i. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.

j. Steel cylinder shall be subject to no more than the lesser of 15,000 pounds per square inch or 50 percent of the steel yield stress.

3. Materials:
   a. Cement: ASTM C 150, Type II, low alkali.
   b. Gaskets shall be as specified in Section 15052 and meet the following requirements:
      1) Minimum tensile strength, tested in accordance with ASTM D 412, between 2,000 and 2,700 pounds per square inch.
      2) Minimum elongation, tested in accordance with ASTM D 412, between 350 and 400 percent.
      3) Shore A durometer hardness, tested in accordance with ASTM D 2240, between 50 and 65.
      4) Specific gravity, tested in accordance with ASTM D 297, between 0.90 and 1.50.
      5) Maximum compression set, tested in accordance with Method B of ASTM D 395, 20 percent.
      6) Maximum tension strength loss, tested in accordance with ASTM D 573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
      7) Maximum elongation loss, tested in accordance with ASTM D 573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
      8) Maximum absorption, tested in accordance with ASTM D 471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.

4. Fabrication:
   a. Joints: Except as otherwise specified or indicated on the Drawings, provide bell and spigot type joints with rubber gaskets.
      1) Bell and spigot rings: Rolled Carnegie shape M-3516.
b. Flanges: AWWA C207, Class D, steel ring, and as follows:
   1) Match pipe flanges to the valve flanges.
      a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
      b) Apply cement-mortar lining and coating to the steel pipe section.
   c. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
   d. Bend radii of fittings: Not less than 2.5 times the nominal diameter.

PART 3 EXECUTION

3.01 INSTALLATION

A. Joints:
   1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is specified in the Piping Schedule in Section 15052.
   2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
   3. Unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052, pipe joints shall be as follows:
      a. Pipe smaller than 2 inches in nominal diameter shall have screwed joints or flexible couplings.
      b. Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
      c. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

B. Screwed joints:
   1. Perform threading with clean, sharp dies.
      a. Wavy, rough, or otherwise defective pipe threads are not acceptable.
   2. Make screwed joints tight and clean with an application of Teflon tape or approved paste compound applied to the male threads only, except as follows:
      a. Make up liquid and dry chlorine lines, and liquefied petroleum gas lines, with litharge and glycerin.
   3. Provide railroad type unions with bronze-to-iron seat, galvanized where used with galvanized pipe.
      a. Flanged joints may be used instead of unions.

C. Flanged joints:
   1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
   2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
   3. Secure welding neck flanges with full penetration butt welds without backing rings.
      a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.
D. Welded joints:
   1. Welded joints shall be electric welded in accordance with AWWA C206.
   2. Welders shall be qualified pursuant to the provisions of AWWA C206.
      a. Welders' testing shall be at the CONTRACTOR's expense, including cost of
         test nipples, welding rods, and equipment.
   3. Do not weld galvanized pipe.

E. Lining and coating:
   1. Field paint aboveground steel pipe as specified in Section 09960.
   2. Field applied cement-mortar lining shall be of the same density, smoothness,
      and thickness as shop applied lining, and in accordance to applicable portions
      of AWWA C602.
   3. Plastic tape wrap application procedures shall be in accordance with
      manufacturer's published instructions.
      a. Apply primer with brush, without runs and drips.
      b. Lap wrapping not less than 1/2 inch. A single wrap lapped 50 percent or
         more will not be acceptable.
      c. Application on welded joints:
         1) Remove sharp edges of weld spatter and slag with a file or ball peen
            hammer before wrapping welded joints.
         2) Apply a single thickness of tape base wrap over the primer, around
            the weld.
         3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape
            over the joint holding the proper tension and overlap, and finish
            4 inches back on the pipe wrap on the other side of the joint.
         4) Apply final wrapping in same manner.
      d. Wrap fittings, valves, and other odd shaped components in the pipeline
         with first and finish wrapping over the prime coat.
      e. Wrap joints, fittings, valves, and other irregular shapes of piping with
         extruded coatings with tape as specified in this subparagraph.
   4. Protect lining of fabricated steel piping fittings and specials during hauling,
      installation, and operation.
   5. Finish joints of fabricated steel piping fittings and specials as specified for pipe
      lining after field welding is done.
   6. After final field welding of fabricated steel piping fittings and specials, complete
      the lining and exterior painting at and near the welded connections.
      a. Repair or replace lining damaged as a result of welding heat, handling, or
         other causes.

3.02 FIELD QUALITY CONTROL

A. Testing: Fabricated steel manifolds shall be field tested with the pipe to which they
   connect.

B. Holiday detection testing of plastic tape wrap coatings:
   1. Perform a complete high voltage electrical inspection (holiday detection
      testing) of all steel piping systems and fittings coated with plastic tape wrap
      prior to burying.
      a. Perform high voltage electrical inspection in strict accordance with
         NACE RP0274-74.
b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.

c. Repair all holidays and defects found in the coating system through the high voltage electrical inspection in strict accordance with the tape coating manufacturer's recommendations.

d. Retest repaired areas in the coating prior to burial of the piping to ensure that all holidays and defects in the coating have been properly repaired.

2. Before conducting holiday detection testing on any piping systems, submit to the ENGINEER for review and approval technical literature and data describing the testing instrumentation, equipment, electrodes, and other accessories that will be used.

a. The literature and data shall include complete information covering the operation and use of the testing equipment, including operational voltage ranges.

3. All holiday detection testing and coating repair work shall be witnessed, inspected and approved by the ENGINEER.

C. Holiday detection testing of extruded coatings:

1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with extruded high-density polyethylene prior to burial of the pipe.

2. Perform the high voltage electrical testing as specified under the preceding paragraph “Holiday Detection Testing of Plastic Tape Wrap Coatings.”
SECTION 15252C

STEEL TRANSMISSION PIPELINES 24 INCHES - 54 INCHES DIAMETER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes steel transmission piping 24 inches through 54 inches in nominal diameter and internal pressures up to 150 pounds per square inch, including joints, fittings, pipe lining, and coating.

B. The CONTRACTOR is required to design, fabricate, and install the piping and all appurtenances in accordance with the requirements of the specifications and Drawings.

C. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02300 - Earthwork
      b. Section 02318 - Trenching
      c. Section 09960 - Coatings.
      d. Section 13112 - Pipeline Corrosion Monitoring Facilities.
      e. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

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

B. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings.
   2. Boiler and Pressure Vessel Code.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   4. C206 - Field Welding of Steel Water Pipe.
   5. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches through 144 inches.

D. ASTM International (ASTM):

1.03 DEFINITIONS

A. Buried Pipe: Pipes that are buried directly in the soil and pipes that are cast in a concrete encasement.

B. Concrete Embedded Pipes: Pipes that are embedded in a concrete structure.

C. Exposed Pipes: Pipes that are exposed and are not buried. Within a structure, the pipes may be above or below the finish grade surrounding structure.

1.04 SUBMITTALS

A. CONTRACTOR shall complete utility potholing and submit all information for the ENGINEERS review prior to submitting shop drawings for pipe layout under this specification. Failure to comply with this requirement shall constitute an automatic rejection of the pipe material submittal.

B. CONTRACTOR shall submit detailed shop drawings of the piping, joints, fittings and all other appurtenances. Shop drawings shall show the field location and number of each fitting and pipe section in relation to the stationing shown in the Drawings. The shop drawings shall include the following minimum information:
   1. Pipe wall thickness.
   2. Joint design and type.
   3. Details of interior and exterior lining and coating required.
   4. Details of any special fittings.
   5. Details of any thermal expansion/contraction segments required.
   6. Testing of protective coating and lining:
      a. Pipe cylinder manufacture:
         1) Cement Mortar Lining:
            a) Submit test results for cement mortar lining in accordance with AWWA C205.
         2) Cement mortar coating:
a) Submit test results in accordance with AWWA C205 on cement mortar coating.

C. CONTRACTOR shall submit weld design calculations for thrust restraint welds.

C. CONTRACTOR shall submit weld design calculations for thrust restraint welds and indicate locations and lengths where piping will require single or double welds.

D. CONTRACTOR shall submit cut sheets and all details of the rubber gaskets for the piping joints.

E. CONTRACTOR shall submit design calculations stamped by a professional engineer registered in the State of California. The calculations shall be performed per the requirements of section 2.01 of this specification.

F. Certificates of Compliance:
   1. Per AWWA C200.
   2. Mill Steel Certificates.
   3. ISO 9000 or Lloyds Registry.

G. Certifications:
   1. Prior to shipment, the Pipe Manufacturer shall submit the following:
      a. A Certificate of Adequacy of Design stating that the pipe to be furnished complies with AWWA C200, AWWA C205, AWWA C222, and these specifications.
      b. Copies of results of factory hydrostatic tests shall be provided to the ENGINEER.
      c. Mill certificates, including chemical and physical test results for each heat of steel.
      d. Certified test reports for cement mortar test.
      e. Certified test report for steel cylinder tests.

H. Submit current American Welding Society (AWS) welding certifications for all personnel performing field welds. Submit welding certifications 30 days prior to performing any field welds.

I. Submit mill certificates, or certificates from approved testing laboratory or other source acceptable to the Engineer, for the steel used for pipe cylinders, showing conformance to appropriate ASTM Specifications including chemical and physical characteristics.

J. Testing Plan: Submit a testing plan that provides details associated with the hydrostatic testing of the pipeline. The testing plan shall include, but not be limited to, providing the details of the testing apparatus set up, pressure gauges, source of water, disposal of water, temporary dished heads, anticipated fill, stabilization, testing durations, safety program associated with the hydrostatic tests, and other information required for a successful test. The testing plan shall meet additional requirements and specification 15956.
1.05 QUALITY ASSURANCE

A. General: Provide new pipe, fittings, and appurtenances fabricated for this project. The piping shall not be from the manufacturer’s inventory.

B. Manufacturer’s qualifications: Provide products from manufacturer experienced in design, and manufacture of pipe material for purpose required, and who has established record of manufacturing of such pipe. Submit references giving location, service, and contact person and contact phone number and e-mail address for 3 similar pipelines now in service. All the pipe, coatings, and fittings for the project must be manufactured at the same facility.

C. The pipe manufacturer must meet one or more of the following certification programs:
   1. ISO 9001 Certification.
   2. Lloyd’s Registry Certification.

D. If an alternative product manufacturer is proposed, demonstrate to the satisfaction of the ENGINEER that the quality is equal to the materials and equipment made by:
   1. Ameron International.

E. The pipe manufacturer shall have the capability of installing the cement mortar lining. Information on pipe manufacturer qualifications shall include experience with cement mortar linings.

F. The pipe manufacturer shall have the capability of applying the cement mortar coating. Information on pipe manufacturer qualifications shall include experience with cement mortar coatings.

G. Warranty:
   1. The CONTRACTOR shall warrant, and shall obtain from the manufacturer its warranty, that the pipe conforms to these specifications and will be free from defects in materials and workmanship for a period of 5 years from the date of Substantial Completion of this Contract. Said manufacturer’s warranty shall be in a form acceptable to, and for the benefit of, the OWNER, and shall be submitted as a condition of final payment.
   2. The CONTRACTOR shall repair or replace, at the sole option of, and at no cost to the OWNER and their representatives, any work found to be defective within said warranty period. Such repair or replacement shall include the cost of removal and reinstallation, inspection, and acceptance testing.
   3. The CONTRACTOR shall also warrant to the OWNER that the materials used on this Contract, where covered by patents or license agreements, are furnished in accordance with such agreements and that the prices included herein cover all applicable royalties and fees in accordance with such license agreements.
   4. The CONTRACTOR shall defend, indemnify, and hold the OWNER and their representatives harmless from and against any and all costs, loss, damage, or expense arising out of, or in any way connected with any claim or infringement or patent, trademark, or violation of license agreement.
1.06 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store, and handle pipe in accordance with AWWA C200, M-11 and as required in this specification.

B. Preparations for shipping:
   1. Minor repairs to cement mortar lining or coating:
      a. If the repair area exceeds 100 square inches, reject the pipe sections and do not allow repairs.
      b. Only 2 repaired areas are allowed to the coating and lining of each pipe section in the field or the plant.
      c. Do not make minor repairs without prior acceptance by the ENGINEER of the written repair procedures.
      d. Compact coating repairs to the same density as the original machine applied mortar.
      e. Do not apply curing compound to the repair where a barrier coating is specified over the mortar coating.
      f. Repair in accordance with AWWA C205.

C. Stulling:
   1. Greater than 30 inch to 48 inch diameter pipe:
      a. Install nominal 3 inch by 3 inch, 4-point wooden stulls or equivalent with nailed wooden wedges at the quarter points, following the cure of the lining.
      b. Install a similar single strut 2 feet from each end of the pipe.
   2. 30 Inch and smaller diameter pipe:
      a. Install 2-inch by 4-inch (nominal) stulls both ways 2 feet from the end of each pipe.
   3. Keep the stulls in place during:
      a. Subsequent manufacturing process and curing.
      b. Transportation to the project site.
      c. Placement in the trench for pipe 30 to 42 inches in diameter
         1) Horizontal stulls must be removed prior to backfilling.
         2) Vertical stulls should remain in place until after the trench is backfilled.
   4. Remove stulls prior to testing.
   5. Temporary removal of stulls will be allowed for repairs to the lining.

D. Plastic covers:
   1. Attach to the ends of the pipe and fittings during curing of lining storage and shipment, and on the installation site. They may be removed just prior to installation.
   2. Banding:
      a. Steel bands, or
      b. Reinforced plastic straps.
   3. Temporary holes may be cut into the covers during curing or to add water to facilitate repairs. Promptly tape the holes closed after completing the curing or repair.

E. Loading, transporting, unloading and handling pipe and fittings:
   1. Handle pipe in a manner and by methods that prevent damage to pipe, lining, and coatings.
2. Use padded slings and supports during handling as necessary to prevent damage.
3. Take all necessary precautions to maintain the integrity of the coating.
4. Handle pipe with proper equipment and do not push or drag along the ground.
5. Do not stack or otherwise loaded externally pipe such that the dimensional integrity of the joint configuration and/or roundness of the pipe may be compromised.

F. Storage:
1. Store pipe and fittings on skids, sand or dirt berms, sand bags, or other suitable means to prevent damage to pipe and fittings.
2. Store and protect pipe from damage from equipment, traffic, and vandalism.

G. Inspection:
1. Inspect pipe lining and coating immediately before installation for damage and holidays.
2. Repair damaged pipe lining and coatings or reject in accordance with specified criteria for identifying and making minor repairs.
3. Remove rejected pipe from the project site.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Design requirements: The CONTRACTOR shall design the steel piping, fittings, and specials in accordance with AWWA M-11 and according to the following modifications:

1. Pipeline Pressure Design Requirements:
   a. Working Pressure: 150 psi
   b. Test Pressure: 100 psi
   c. Surge Pressure: 1.5 times the working pressure (225 psi)
   d. Internal Negative Pressure: 14.7 psi

2. Steel Cylinder Requirements:
   a. Design the steel cylinder to 50 percent of the steel yield stress for the working pressure and 75 percent of the steel yield stress for the surge pressure.
   b. The maximum allowable steel yield stress is 42,000 psi; refer to section 2.02 for additional requirements.

3. Thrust Requirements:
   a. Bends over 5 degrees are required to be restrained, as shown in the Drawings. The restraint system for steel pipe shall be welded joints.
   b. The length (L) of pipe to be restrained shall be calculated by the CONTRACTOR, the restraint length must extend up to the full length required by the CONTRACTOR’S calculations or the minimum length shown on the Drawings, which ever is greater. The restraint must extend beyond the nearest piping joint (i.e. round up to the nearest full length). Calculations shall be per AWWA Manual M-11 equation (13-6) using the following criteria:
      1) Coefficient of friction between soil and pipe (\(\mu\)): 0.20
      2) Internal Pressure (P): 1.5 times the working pressure
2) **Internal Pressure (P):** Equivalent to working pressure design requirement.

3) The dead and live loads for the restraint calculation shall be per section 2.01.4.e of this specification.

c. **Where the CONTRACTOR’S calculations require restraint, or where restraint is shown on the Drawings:** CONTRACTOR shall design the pipe restraint welds for thrust generated at the working pressure of the pipe (150 psi). Steel piping shall be restrained by welding the interior and/or exterior of the piping joint.

c. **Where the CONTRACTOR’S calculations require restraint, or where restraint is shown on the Drawings:** CONTRACTOR shall design the pipe restraint welds for thrust generated at the working pressure of the pipe (150 psi). Steel piping shall be restrained by welding the interior and/or exterior of the piping joint. Double welding (welding of the interior and exterior of the piping joint) will be required on each side of restrained joints. Lengths and locations of double welding to be calculated and determined by the CONTRACTOR and submitted to the ENGINEER for review and approval.

d. Piping shall be restrained in the locations shown in the Drawings. Thrust blocks are not an acceptable means for restraining pipe.

4. **External Load Design Requirements:** CONTRACTOR design the pipe, fittings and specials in accordance with AWWA Manual M11 with the following modifications:

a. **Steel wall thickness:** As designed by the CONTRACTOR, or the minimum thickness as specified in this section, whichever is thicker.

b. **Maximum deflection of pipe and fittings of 1.5 percent when the pipe is designed for this project using the criteria in this section.**

c. **Working stress of steel:** Maximum 50 percent of yield stress for internal working pressure design and 75 percent of the steel yield stress for the surge pressure design.

d. **Weight of local soil or backfills:** Use 140 lb/ft³.

e. **Calculate the dead and live load for the pipeline design using the following formula:**

\[ W_T = W_C + W_L \]

The terms in the equation are defined below:

- **\( W_T \):** Total load on pipe, pounds per linear foot of pipe.
- **\( W_C \):** Earth load, pounds per linear foot of pipe calculated as outlined in M11 (prism load) and using the weight of local soils or backfills.
- **\( W_L \):** Live loads, pounds per linear foot of pipe, as outlined in AWWA M11. Add AASHTO's H-20 loading to earth loads for all below grade locations.

f. **A Bedding constant \( K = 0.100 \) and a Deflection Lag Factor of 1.50.**

g. **Use only the area of the steel to calculate the total pipe stiffness. Do not include the area of the lining or coating in the calculation.**

h. **\( E'_{\text{COMBINED}} \):** Composite modulus of soil reaction, as determined by the geotechnical engineer: 1,400 psi (maximum allowed).
5. Minimum Steel Cylinder Thickness: Minimum 0.1875 inches.
6. Pipe manufacture shall confirm that the pipe bedding material selected by the Contractor has a minimum E’ of 2,000 psi at the compaction rate specified.

2.02 MATERIALS

A. Steel pipe, fittings, and specials:
   1. General:
      a. Steel pipe in accordance with AWWA C200, and as specified.
      b. Fittings and specials dimensions in accordance with AWWA C208.
      c. Provide identification marks in accordance with AWWA C200.

B. Steel Pipe Cylinders:
   1. Fabricated in accordance with AWWA C200 as modified by this Section:
      a. Steel: ASTM A 1018. Maximum yield strength shall be 42,000 pound per square inch.
      b. Steel: ASTM A 1018. Yield strength used for design shall range from 32,000 to 42,000 pound per square inch.
      c. All steel used for fabrication shall have a maximum carbon content of 0.25 percent, a maximum sulfur content of 0.015 percent.
      d. Minimum Elongation in 2 Inch Gauge Length: 21 percent.
      e. Weld Ability: Maximum carbon equivalent of 0.45, as measured using AWS D1.1, Annex XI, Guideline on Alternative Methods for Determining Preheat Formula:

         \[ CE = C + \frac{(Mn + Si)}{6} + \frac{(Cr + Mo + v)}{5} + \frac{(Ni + Cu)}{15} \]

      e. Steel used for fabrication exceeding 0.375 inches in thickness shall be tested for notch toughness using the Charpy V-Notch Test in accordance with ASTM A 370. The steel shall withstand a minimum impact of 25 foot pounds at a temperature of 30 degrees Fahrenheit. Test outside diameter wrap of 2 coils minimum per heat lot.
      f. Steel shall be fine-grained, fully killed, and manufactured by the continuous casting process.

   2. Pipe Cylinders: Substantially true right cylinders formed from sheet, plate, or coiled steel:
      a. The difference in diameter between major and minor axes shall not exceed 1 percent of the diameter of the pipe.
      b. Straightness of pipe cylinders shall be such that no point on the surface of the pipe cylinder shall deviate more than 1/8 inch in any 10 foot length as measured by a straight edge.
      c. Circumferential welds are not acceptable.
      d. Sheets, plates, or coils from the mill shall not contain welded seams.
      e. Maximum length of pipe cylinder shall be 50 feet.

   3. Type of Welding: Limited to the following methods unless other methods are accepted by Construction Administrator:
      a. Submerged arc welding (SAW).
      b. Shielded metal arc welding (SMAW).
      c. Flux cored arc welding (FCAW).
      d. Resistance seam welding (RSEW).
4. Welding of Longitudinal Seams:
   a. Use full penetration butt welds.
   b. Fabricated pipe with longitudinal seams parallel to the axis of the pipe: Use no more than 3 longitudinal seams.
   c. Seam Weld: Have a strength of at least 100 percent of the specified minimum yield strength of the adjacent sheet.
   d. Thoroughly clean and properly form edges before welding. Forming of material shall not be done by means of hammering. Clean surfaces at least 1/2 inch from the weld joint in addition to the surface to be welded.
   e. Weld bead shall be central to the seam and free from depressions, undercut edges, burrs, irregularities, and valleys.
   f. Weld shall be continuous for full length of seam.
   g. Build up arc welds uniformly at the center of the weld and have complete penetration. Height of weld bead above plate surface shall not exceed 1/32 inch on the outside nor more than 3/32 inch on the inside. Ground welds shall be smooth and free of burrs. Do not grind into, or gouge, the adjacent pipe wall material.
   h. Fuse welds with base metal, uniform in appearance, free from cracks, and reasonably free from irregularities.
   i. Scattered porosity and slag inclusions in accordance with the Standards of Section VIII of the ASME Boiler and Pressure Vessel Code will be acceptable.
   j. Chip, flame gouge, or air arc gouge unacceptable defects to sound metal and rewelded by either manual or automatic welding.
   k. The portion of the weld that must be removed shall be as directed by the Construction Administrator.
   l. Restart the welding operation on clean and sound metal.
   m. Welding technique shall ensure uniform distribution of residual stresses in the weld or adjacent metal. Undercutting will not be permitted.
   n. Weld beads on the outside of plain or spigot ends and on the inside of bells shall be ground flush for a distance of 4 inches from the ends of cylinders.
   o. Butt welds made by the resistance seam welding method shall have no buildup either internally or externally. Pipe made by this method shall be cleaned of all material formed during the welding process beyond the outside circumference of the cylinder.
   p. Diameter designation: The pipe diameter specified or indicated on the Drawings is the nominal diameter of the pipe. For the clear inside diameter after application of the lining and for tolerances see the table in this section.

<table>
<thead>
<tr>
<th>Nominal Diameter</th>
<th>Clear Inside Diameter after Application of Lining &amp; Coating (in)</th>
<th>Tolerances (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>24</td>
<td>Minus 0 plus 3/16</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>Minus 0 plus 3/16</td>
</tr>
<tr>
<td>36</td>
<td>36.5</td>
<td>Minus 0 plus 1/4</td>
</tr>
<tr>
<td>42</td>
<td>42</td>
<td>Minus 0 plus 1/4</td>
</tr>
</tbody>
</table>
2.03 FABRICATION

A. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.

B. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.

C. Fabricate fittings and specials to allow field assembly without cutting or special work.
   1. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
   2. Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment.

2.04 LINING - STEEL PIPE FITTING AND SPECIALS

A. General: Mortar line steel pipe except where otherwise specified or indicated on the Drawings.
   1. Finish joints of fabricated steel piping fittings and specials as specified for pipe lining after field welding is complete.

B. Cement Mortar Lining:
   1. Schedule: As indicated in schedule.
   2. Cement Mortar Lining:
      a. In accordance with AWWA C205, except as modified in this Section. Proportion of portland cement, sand, and water will be determined by the manufacturer to provide a compressive strength of 4,500 pounds per square inch at 28 days:
         1) Proportions by Weight of Portland Cement to Sand: Approximately 1:3.
         2) Portland Cement: Type II in accordance with ASTM C 150.
         3) Water Soluble Chloride Ion Content of the Mortar: Not exceed 150 milligrams in 1,000 grams of mortar.
         4) Lining: NSF 61 approved for potable water.
         5) Lining Thickness: 1/2 inch with a tolerance of plus 3/16 inch and minus 1/16 inch.
      b. Compressive Strength: Determine using samples made from a small spinning device with a steel cylinder dimensioned in accordance with the standard test cylinder as described in ASTM C 31. Mortar shall be spun in the cylinder with a thickness of at least 1-1/2 inches. Remove mortar from the mix in accordance with ASTM C 172. Curing of test specimens shall be the same as curing the pipe. The specimens shall then be tested in accordance with ASTM C 39, using the net mortar area to determine the compressive strength. If laboratory facilities are not available at the plant, then the tests shall be made by a testing laboratory acceptable to the Construction Administrator. Results of compressive strength tests shall be submitted.
      c. Pipe Cement Mortar Lining Equipment: Use a centrifugal lining machine.
      d. Application of Cement Mortar Lining:
1) Line after completion of shop tests and after the interior has been cleaned of loose rust, scale, or foreign matter.

2) Install round-up rings at each end of pipe and install exterior ring beams before spinning the lining. Rings and beams shall remain in place until the lined pipe section is supported for curing on sand ribbons. Acceptable alternative method is to support pipe on cable slings during initial curing prior to coating.

3) The number and spacing of ring beams shall be adequate to maintain a rigid and round pipe section within the specified tolerance.

4) The mortar shall be deposited by a method, which allows a regulated and uniform quantity of material to be applied throughout the entire length of pipe. Confinet lining to dimensions indicated on the Drawings for the pipe.

5) Finished lining shall have a smooth, hard, dense, and non-gritty surface free from defects.

e. Curing Mortar Lining:
   1) Start curing as soon as lining has set.
   2) Moist Curing:
      a) Cure for not less than 4 days.
      b) Surface must be kept continuously wet by sealing the pipe ends airtight or by other methods acceptable to Construction Administrator.
      c) Accelerated Curing: Steam curing may be used to speed the curing or until it has gained sufficient strength to be handled:
         (1) Start 3 to 6 hours after lining has been applied.
         (2) Steam shall be saturated vapor at 100 degrees Fahrenheit to 130 degrees Fahrenheit maximum.
         (3) Steam curing chambers shall protect pipe from drafts.
         (4) Protect from rapid drops in temperature after curing.
      d) Each 1-hour of steam curing will reduce the required 4 day water cure by 4 hours.

f. Handling Cement Mortar Lined and Coated Pipe Cylinders:
   1) Support lined or coated pipe by belt slings or shaped rubber pads. Providing at least 90 degree support during all handling operations.
   2) Do not roll lined or coated pipe at any time.
   3) Prevent slipping or sloughing of new lining.
   4) Cut out and reline damaged lining.

g. Protection of Lining during Water Curing:
   1) Protect against lining being heated by the atmosphere or direct sunlight to above 100 degrees Fahrenheit. Cover with burlap or other suitable material acceptable to Construction Administrator. Keep cover continuously wet.

h. Reinforcement: Reinforce lining of fittings and specials, 24 inches in diameter and larger with wire mesh if not cutout of straight pipe previously lined.

2.05 COATING - STEEL PIPE, FITTINGS AND SPECIALS

A. General:
   1. Coat steel pipe in accordance with AWWA C205, modified as follows:
3. Mortar coat outside pipe surfaces of steel pipe, except when otherwise specified or indicated on the Drawings.
4. Extend pipe coating for underground piping 6 inches above finish grade or 3 inches above finish floor, and neatly terminate.
5. Field paint aboveground steel pipe as specified in Section 09960. Cement-Mortar coating:

### 2.06 SOURCE QUALITY CONTROL

**A. Inspection of Fabricated Pipe Cylinders:**
1. ENGINEER may inspect all phases of pipe fabrication work and will witness all tests.
2. Notify ENGINEER to schedule the inspection, at least 1 week prior to start of the fabrication work.
3. Expense of rewitnessing failed hydrostatic tests or reinspection of any phase of pipe manufacture shall be paid by the CONTRACTOR.
4. Expense of rewitnessing or reinspection by ENGINEER shall include the employee’s wages, transportation, lodging, and incidental expenses incurred.
5. Expense of rewitnessing or reinspection by the ENGINEER authorized agent shall be charge to the CONTRACTOR.

**B. Tensile and Bend Tests for Steel Sheet, Plate, or Coil:**
1. Samples for testing may be taken by the ENGINEER for testing.

**C. Qualification of Welding Procedures and Welders:**
1. Shop Welding Procedure: Weld procedure specifications shall be qualified by testing in accordance with ASME Boiler and Pressure Vessel Code, Section IX.
2. Field Welding Procedure: Weld procedure shall be qualified by testing in accordance with AWS D.1.1.
3. Welders:
   a. Welders shall be qualified for the welding process and the procedure to be used under:
      1) ASME Boiler and Pressure Vessel Code, Section IX, Part QW.
      2) AWS D.1.1, Section 5.
   b. Welders shall have verifiable evidence that their qualification is current and valid under the applicable code.
   c. Welder Qualification Certification:
      1) Witnessed and evaluated by a certified AWS QC1 welding inspector utilizing calibrated equipment.
   d. CONTRACTOR shall test welders at its expense.
4. Notch-tough welding that requires heat input control is required for all pipe and specials with steel thickness greater than 0.375 inches:
   a. Welding procedure specification used for shop fabrication of pipe shall be qualified in accordance with ASME Boiler and Pressure Vessel Code SEC IX and shall include Supplementary Essential Variables.
   b. Welding procedure specification used to install pipe in the field shall be qualified for heat input control in accordance with AWS D1.1.
   c. PQRs shall be qualified for notch tough welding with consideration for thickness of steel, test temperature, and Charpy V-notch values. Charpy V-Notch testing shall be in accordance with AWS D1.1, Section 4, Part D,
Operation A (3 specimens). See Article 2.01.B.1.e for Charpy V-Notch Acceptance Criteria. Using this test procedure, select:
1) Test temperature and minimum average energy level for Charpy Testing.
2) Welding position as it may relate to heat input on the heat affected zone test results.
3) Orientation of the test plates as these relate to the longitudinal or transverse properties of the heat affected zone.

D. Cylinder Fabrication Welding Tests Performed by the CONTRACTOR: Tension tests, bend tests, and radiographic tests:
1. Cut tension test and bend test coupons from pipe cylinder for testing of welded seams. There shall be at least 1 set of test coupons taken from each heat of steel and at least 1 set of test coupons taken of each size, grade, and wall thickness from each welding machine and each operator at a minimum of every 1,000 feet of pipe. Test in accordance with AWWA C200, Section 4.11. Welded seams shall develop the ultimate strength specified for adjacent steel.
2. Perform Spot Radiographic Examination of Welds: Tests shall be in accordance with paragraph UW 52 of Section VIII of the ASME Boiler and Pressure Vessel Code.
3. Location for tests will be confirmed by the ENGINEER prior to the testing.
4. Repair cylinder after tests.
5. CONTRACTOR shall pay for all tension tests and bend tests of welded seams. Testing shall be evaluated by a certified AWS QC1 welding inspector utilizing calibrated equipment.

E. Hydrostatic Tests of Steel Cylinders:
1. Shop test each steel cylinder at a pressure to develop a circumferential tensile stress equal to 75 percent of minimum yield point stress for the specified steel used.
2. Determine brittleness of welded cylinder by hammering, on or near each side of each welded seam prior to or during hydrostatic test. Do not hammer hard enough to deform or cause damage to the metal.
3. Maintain pressure during inspection of all seams. Cylinder outer surface shall be dry during inspection.
4. Repair by chipping, grinding, air arcing, and rewelding.
5. Retest all repaired pipe.
6. Cylinders requiring more than 3 percent of any seam to be repaired by hand welding will not be accepted unless repairs are acceptable to the ENGINEER.

F. Testing of Fabricated Fittings:
1. Test all pipe sections to be used for fabricated fittings.
2. Weld Testing:
   a. Test all welded seams not hydrostatically tested by non-destructive methods in accordance with AWWA C200, paragraph 5.2.2.1.
   b. Visually inspect all welds.
   c. Test welds by the liquid penetrate inspection procedure in accordance with to ASTM E 165, under Method “B.”
3. Testing of Welds for Fittings:
   a. All welds shall be reviewed by the pipe manufacturers’ certified welding inspector in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
b. Butt-welds shall be radiographically examined in accordance with ASME Boiler and Pressure Vessel Code Section VIII, Division 1, paragraph UW 52.

c. All other welds shall be 100 percent examined using magnetic particle testing in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

G. Protective Lining and Coating of Pipe Cylinder:
1. General: The protective coating and lining of pipe cylinders shall be the same type as required for the pipe where the pipe cylinder is used.
2. Test cement mortar lining in accordance with AWWA C205.
3. Test cement mortar coating in accordance with AWWA C205.

2.07 IDENTIFICATION OF PIPE AND FITTINGS

A. Pipe Cylinders:
1. Each length shall be plainly marked on the outside with a manufacturing number, metal stamped 1 inch from the end. This number shall be used in the pipe cylinder manufacturing and hydrostatic tests to trace the steel used in manufacturing.
2. Transfer this number, by metal stamping, to all pieces to be cut from cylinder, prior to cutting cylinder.

B. Pipe:
1. Pipe designations as indicated on the Drawings shall be plainly marked on the lining and coating on each length of pipe, 1 foot from the bell end. In addition, the date of final coating and identification to show proper location and orientation in the pipeline, by reference to layout drawings or schedules, shall be shown.
2. Beveled pipe shall be marked to show degree of bevel, point of maximum pipe length at the spigot end, and the field top at each end.
3. Pipe sections containing angle bends, manholes, or nozzles shall be stenciled on the lining and coating at both ends.
4. Mark vertical field top on each end of each pipe.

C. Fittings and Specials:
1. Mark with appropriate identifying number or symbol indicating its location and orientation in the pipeline.
2. Mark vertical field top on each end of each fitting and special.

2.08 STEEL PIPE JOINTS AND CONNECTIONS

A. General:
1. Joints:
   a. Provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller, except as otherwise specified or indicated on the Drawings.
   b. Use lap joints on field-welded joints for restraint.
   c. Use butt-strap joints only where required for closures or where indicated on the Drawings.
   d. Provide deep bells where required by the CONTRACTOR'S design calculations for shrinkage and/or expansion control joints.
e. Provide joints with the same or higher pressure rating as the abutting pipe.

2. Connections:
   a. Make connections to existing systems using a flange isolation joint.
   b. If an existing pipeline or facility does not include a flange at or near the connection point, place an isolation flange in the first length of pipe.
   c. Use a butt-strap joint to connect the first length of pipe to the existing pipeline.

B. Bell and spigot joint rings:
   1. Rolled-groove or Carnegie shape with rubber gaskets.
   2. Rubber gasket requirements:
      a. Minimum tensile strength, tested in accordance with ASTM D 412, between 2,000 and 2,700 pounds per square inch.
      b. Minimum elongation at rupture, tested in accordance with ASTM D 412, between 350 and 400 percent.
      c. Specific gravity, tested in accordance with ASTM D 297, between 0.90 and 1.50.
   3. Furnish joints with recesses in the coating or lining exposing the joint for attachment of electrical bonds. Install 2 exterior or interior recesses at each joint.

C. Flanges: AWWA C207, Class D, Pressure Class 150 steel ring, and as follows:
   1. Match pipe flanges to the valve flanges.
   2. Provide a shop coating of primer on flanges and portions of pipe not covered with cement-mortar.
   3. Flange bolts: As specified in Section 15052.
   4. Provide washer on the nut end of each bolt to protect the flange coatings.
   5. Gaskets: As specified in Section 15052.

D. Welded joints (Where restraint is required):
   1. Lap welded joints:
      a. Lap joints prepared for electric field welding in accordance with AWWA C206.
      b. Joint forming:
         1) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
         2) Form bell ends by and expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.
      c. Provide surfaces of the bell and spigot that are essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

E. Field fabrication or cutting is not allowed unless otherwise approved by the ENGINEER.
PART 3 EXECUTION

3.01 INSTALLATION

A. Cleaning: Thoroughly clean pipe and fittings before placement.

B. Pipe Handling:
   1. Pipe shall be handled at all times with a minimum of two wide non-abrasive slings, belts or other equipment designed to prevent damage to the coating or lining.
   2. The equipment shall be kept in such repair that its continued used is not injurious to the coating.
   3. The spacing of pipe supports required to handle the pipe shall be adequate to prevent cracking or damage to the lining or coating.

C. Line Up at Bends:
   1. Line up pipe for joining so as to prevent damage thereto.
      a. Thoroughly clean the bell and spigot ends of each joint of pipe of foreign matter, rust and scale before placing spigot into bell.
   2. Where abrupt changes in grade and direction occur, employ special shop fabricated fittings for the purpose.
      a. Field cutting the ends of the steel pipe to accomplish angular changes in grade or direction of the line shall not be permitted.

D. Pipe laying:
   1. Lay pipe to the lines and grades indicated on the Drawings unless they are amended or supplemented by the manufacturer's tabulated lay schedule and accepted by the ENGINEER.
   2. Lower pipe into the trench slowly and gently with slings or properly padded calipers.
   3. Make the bell end of the pipe face the direction of laying wherever practicable.
   4. Keep the pipe trench free from water which might impair the bedding or joining and welding operations.

E. Joints:
   1. Gasket joints:
      a. Lubricate the spigot groove, and the first 2 inches of the bell, with an approved soft vegetable soap compound.
      b. Position the gasket in the spigot groove such that the rubber is distributed uniformly around the circumference.
      c. Lay the pipes in such manner that the blockouts on the interior linings are at the spring line of the pipe to facilitate electrical connection of adjacent pipes.
      d. The width of the space provided at the joint may be varied to compensate for the permissible manufacturing tolerance in pipe lengths plus or minus 1/4 inch to maintain the laying length indicated on the Drawings and lay schedule.
      e. Place metal or wooden spacers against the inside shoulder of the bells.
      f. Joints may be pulled on one side and most joint designs can be closed on the opposite side of pipe for long radius curves and slight changes or correction of alignment and grade. Do not exceed the pipe manufacturer
recommendation on the amount of joint deflection for the type and size of the joint being used.

f. **Joints may be pulled on one side and most joint designs can be closed on the opposite side of pipe for long radius curves and slight changes or correction of alignment and grade. The maximum allowable joint deflection is 2 degrees at each joint.**

g. Insert a thin metal feeler gauge between the bell and spigot after the joint is assembled in order to check the position of the gasket around the complete circumference of the pipe.

h. If the gasket is not in its proper position, disassemble the joint and inspect the gasket for cuts or damage.
   1) If gasket is damaged relay the pipe with a new gasket.
   2) If the gasket is not damaged, relay the pipe.

i. Install 2 interior or exterior bonding clips at each joint.

2. **Flange joints:**
   a. **Flanges:**
      1) Apply cement-mortar lining and coating to the steel pipe section.
      2) Coat buried flanges with Plastic Tape Wrap Coating.
   b. **Flange bolts:** As specified in Section 15052.

3. **Welded joints:**
   a. Use lap type electric welded joints for field welded joints in accordance with AWWA C206. Perform field welding by welders certified by ASME Boiler and Pressure Vessel Code.
   b. Where exterior welds are performed, provide adequate space for welding and inspection of the joints.
   c. During installation of welded steel pipe in either straight alignment or on curves, lay the pipe so that at any point around the circumference of the joint where is a minimum lap of 1-1/2 inch and a minimum space of 1 inch between the end of the fillet weld or the spigot end of the pipe and the nearest tangent to a bell radius.
   d. Prior to the beginning of the welding procedure, remove any tack welds used to position the pipe during laying.
      1) Equally distribute any annular space between the faying surfaces of the bell and spigot around the circumference of the joint by shimming, jacking, or other suitable means.
   e. Make weld in accordance with AWWA C206.
      1) Where more than 1 pass is required, peek to relieve shrinkage stresses on each pass except the first and final one; and remove all dirt, slag and flux before the succeeding bead is applied.
   f. Place no more than a 1/8 inch of weld material on each weld pass using a combination of stitch and weave weld.

4. **Restrained joints:**
   a. The CONTRACTOR shall design the welded lap joints for restraint for the working and surge pressures listed in this specification. Single or double fillet welds may be required for restraint depending on the CONTRACTOR’S calculations.
      1) It is acceptable to install the single fillet weld on the interior or exterior of the pipeline, if the CONTRACTOR’S calculations show a single fillet weld is acceptable for thrust restraint.
      2) **Double welding (welding of the interior and exterior of the piping joint) will be required on each side of restrained joints. Lengths and locations of double welding to be calculated and**
determined by the CONTRACTOR and submitted to the ENGINEER for review and approval.

b. Restrain with single fillet welds on lap type joints an additional length equal to 25 percent of the length as required by AWWA M11.

5. Shrinkage/expansion control joints:
   a. Location:
      1) At intervals not exceeding 1,000 feet along welded reaches of the pipeline.
      2) The first regular lap-welded field joints outside of each concrete encasement or structure.
      3) Where the shrinkage/expansion control joints occur in a traveled roadway or other inconvenient location, the location of the joint may be adjusted to a convenient location.
   b. Installation:
      1) Lay the pipe with an initial lap of not less than 1 inch greater than the typical lap.
      2) Install welded shrinkage control joint when:
         a) The temperature is approximately the lowest during the workday.
         b) At least 500 feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint.
         c) After backfill has been completed to at least 1 foot above the top of the pipe ahead and in back of the joint.

6. Butt-strap joints, if required for field fit-up:
   a. Shall only be installed if approved by the ENGINEER.
   b. A minimum of 10 inches wide.
   c. The same thickness as the pipe wall.
   d. Provide for a minimum of 2-inch lap at each pipe joint.
   e. CONTRACTOR shall submit a joint stress analysis for butt strap joints on pipelines 36 inches and larger. The analysis shall be stamped by a professional engineer registered in California and consider all forces subjected the pipe (dead load, live load, eccentric forces, etc.).

F. Joint coating:
1. Coat joints on mortar-coated pipe with field placed mortar. Place mortar by:
   a. Placing closed-cell polyethylene strips with cloth backing around the pipe joint:
      1) Using plastic bands at least 8 inches in width.
      2) Centered and secured over the exterior joint recess.
      3) Use box strapping or equivalent methods to bind the band to the pipe so that it encases the outside joint recess completely and snugly.
      4) Provide an opening near the top of the joint.
   b. After the band is secure, moisten the joint recess with water.
   c. Mix mortar grout, consisting of 1 part Portland cement to 2 parts of sand mixed with water to the consistency of thick cream.
   d. Pour mortar grout into the opening to fill the joint recess.
   e. Fill the outside annular space between the ends of the adjacent pipes with the mortar grout for its full circumference.
   f. Do not bed and backfill at the joint until the top opening has been closed and the mortar allowed to take initial set.
g. When using gusset joints with electrical bonds, first moisten the joint recess and the areas over the bonding jumpers and then fill with stiff cement mortar consisting of 1 part Portland cement to 2 parts sand.

h. Encase the entire stranded copper cable in the mortar.

i. This operation should be conducted at least 2 joints from the pipe laying operations.

j. Provide a smooth finished joint.

G. Corrosion protection - Steel pipe: CONTRACTOR shall install corrosion monitoring stations for steel pipe corrosion as specified in Section 13112 and shown in the Drawings.

H. Keep the pipe clean during the laying operation and free of sticks, dirt, animals, and trash.

I. At the close of each operating day, effectively seal the open end of the pipe against the entrance of water using a gasketed night cap.

J. Do not lay pipe in water.

K. Install bonds at all pipe joints, other than welded joints or insulated joints.

L. Joint lining: Line joints on cement mortar lined pipe by hand placing field mixed cement mortar in the joint recess to the level to provide a smooth pipe interior across the joint. The joint material must be properly curved before water is placed into the pipeline.

3.02 FIELD QUALITY CONTROL

A. Perform field-testing as specified in Section 15052.

B. Below grade piping shall be installed to a tolerance of +/- 3 inches horizontal and +/- 1 inches vertical of the horizontal and vertical alignment shown on the Drawings.

C. Mandrel Testing
   1. CONTRACTOR shall perform mandrel testing to confirm roundness of the full-length of the pipeline.
      a. The pipe internal diameter shall be within the tolerances and allowable deflection specified within this specification section.
      b. Mandrel testing shall be performed after backfill is complete with the struts removed immediately before hydrostatic testing.

D. Weld testing:
   1. Liquid penetrant testing: As soon as practicable after welding of each joint, CONTRACTOR shall test field-welded joints by the liquid penetrant inspection procedure in accordance with ASTM E 165 under Method “B” and “Leak Testing.”
      a. The CONTRACTOR shall provide liquid penetrant tests for 20% of all field welds at locations directed by the ENGINEER.
      b. The liquid penetrant testing shall be completed prior to backfill of the pipeline.
   2. Magnetic particle testing: Magnetic particle testing shall be performed by an independent testing laboratory/firm certified for this type of work, which is hired
by the CONTRACTOR and accepted by the ENGINEER, while the welds are being made and after they are completed.

a. Magnetic particle testing shall be performed for 20% of all field welds at locations directed by the ENGINEER.
b. The welds tested with magnetic particle testing shall be in addition to the weld locations tested with liquid penetrant tests.

E. Test results:
1. Chip out, repair and retested all defects.
2. Upon retest, the repaired area shall show no leaks or other defects.
3. Close the threaded openings with pipe plugs or by welding.

3.03 CLEANING

A. Disinfection: Perform disinfection as specified in Section 15052.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

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

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 09910 - Paints.
      b. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

A. ASTM International (ASTM):

1.03 SUBMITTALS

A. Shop drawings:
   1. Layout drawings.
   2. Joints.
   3. Fittings and specials.
   4. Structure and pipe connections.

B. Product data:
   1. Gaskets.

C. Test results.
PART 2  PRODUCTS

2.01 MATERIALS

A. Cast iron soil piping, underground:
   1. Cast iron soil pipe underground: Bell-and-spigot service weight cast iron soil pipe in accordance with ASTM A 74.
   2. Make joints by using positive double seal compression type gaskets in accordance with ASTM C 564.
   3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

B. Cast iron soil piping, aboveground:
   1. Piping: As specified for cast iron soil piping underground, or "No Hub" cast iron soil pipe and fittings:
      a. Couplings for no hub cast iron soil piping: Consisting of a stainless steel corrugated shield and clamp assembly over a molded 1-piece neoprene sealing sleeve, in accordance with ASTM A 888.
   2. Threaded joints: American standard taper screw threads, cut clean and made up with Teflon tape or an acceptable paste thread compound applied to the male threads only.
   3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

C. Acid resistant cast iron piping:
   1. Manufacturers: One of the following or equal:
      b. Provide substitutes from other manufacturers with same chemical properties and weight equal or heavier than the weight of Duriron piping.
   2. Make joints of stainless steel mechanical connectors with Teflon and neoprene liner, or with rope packing recommended by manufacturer.

2.02 FABRICATION

A. Lining and coating:
   1. Line cast iron soil pipe and fittings inside and coat outside with bituminous coating except as follows:
      a. Outside of piping, provide aboveground piping with uncoated outside where piping is specified to be painted as specified in Section 09960.

PART 3  EXECUTION

3.01 INSTALLATION

A. Cast iron soil piping:
   1. Encase in concrete underground cast iron soil piping under structures.
      a. Encase pipe as indicated on the Drawings.
   2. Support aboveground horizontal cast iron soil piping at not more than 5 foot spacing.
   3. Aboveground vertical cast iron soil piping:
      a. Install vertical piping in chases in the wall where the wall is plastered;
where the wall is not plastered, vertical piping may be installed in chases in the wall or may be run exposed.

b. Support vertical pipes at the base and at each floor.

4. Fittings:
   a. Make junctions with sanitary tees or with wyes, with brass screw plug cleanouts at accessible locations at changes in direction.
   b. Make changes in pipe size with reducing fittings.
   c. Make changes in direction by use of 45 degree wyes, half wyes, long sweep 1/4 bends, 1/5, 1/6, 1/8, or 1/16 bends, except that sanitary tees may be used on vertical stacks; short 1/4 bends or elbows 3 inches in size or larger may be used on soil or waste lines where the change in direction of flow is from horizontal to vertical, and on the discharge from water closets.
   d. Cleanouts: Same size as the pipe, except that cleanout plugs larger than 4 inches will not be required.

B. Acid-resistant cast iron piping:
   1. Where rope packing is used, caulk packing into half the depth of the hub.
      a. Ram packing well in accordance with manufacturer's published instructions.
      b. After ramming, fill the joints with lead and caulk in accordance with the manufacturer's published instructions.
      c. Preheat hubs before pouring lead.
   2. Do not use hemp packing and jute packing for joints of acid resistant piping.

END OF SECTION
SECTION 15255

STAINLESS STEEL PIPING AND TUBING

PART 1  GENERAL

1.01 SUMMARY

A. Section Includes: Stainless steel piping and tubing.

B. Related Sections:
   1. Section 05120 - Structural Steel.
   2. Section 09960 - High Performance Coatings
   3. Section 15052 - Basic Piping Materials and Methods.
   4. Section 15121 - Pipe Couplings.

1.02 REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   2. B16.5 - Pipe Flanges and Flanged Fittings.

B. American Society of Mechanical Engineers (ASME):
   1. Boiler and Pressure Vessel, Section IX.

C. American Society for Testing and Materials (ASTM):
   3. A 194 - Specification for Carbon and Alloy Steel Nuts and Bolts for High Temperature and High Pressure Service.
13. A 790 - Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
14. A 928 - Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal
15. A 976 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
16. B 912 - Passivation of Stainless Steels Using Electropolishing

D. American Water Works Association (AWWA):
   1. C 220 - Stainless Steel Pipe, 4 Inches (100 mm) and Larger.

E. Compressed Gas Association (CGA):

1.03 DESIGN REQUIREMENTS

A. Piping Layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints made up in the field are minimized.
   1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every field joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
   2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop Fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field Assembly: Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings. Field welding is prohibited.

1.04 SUBMITTALS

A. Layout Drawings: Detailed layout drawings showing dimensions and alignment of pipes; location of valves, fittings, and appurtenances; location of field joints; location of pipe hangars and supports; connections to equipment or structures; location and details of shop welds; and thickness and dimensions of fittings and gaskets.
   1. Prepare layout drawings.

B. Product Data:
   1. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
   2. Material specifications for pipe, gaskets, fittings, and couplings.
3. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.

C. Manufacturing certifications.

D. Welder and weld operator qualification certificates and welding procedures. A schedule of weld operators and identification symbols, as required in Article 2.01 F.

E. Design pressure de-rating calculations for schedule 40 or schedule 80 pipes that have threaded or grooved connections.

PART 2 PRODUCTS

2.01 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall Thickness:
   1. Piping 3 inches in nominal diameter and greater: Minimum wall thickness corresponding to Schedule 10S.
   2. Piping less than 3 inches in nominal diameter: Minimum wall thickness corresponding the Schedule 40S.
   3. Piping with threaded or grooved joints: Minimum wall thickness corresponding the Schedule 40S.

C. Piping Material and Manufacturing: Comply with the requirements outlined in the following table:

<table>
<thead>
<tr>
<th>Service</th>
<th>Stainless Steel Grade</th>
<th>Pipe Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Other Service Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping less than 3 inches in</td>
<td>Type 304L stainless steel</td>
<td>In accordance with ASTM A</td>
</tr>
<tr>
<td>nominal diameter</td>
<td>conforming to ASTM A 240</td>
<td>312</td>
</tr>
</tbody>
</table>

D. Fittings for Piping Less than 3 inches in Diameter:
   1. Material: ASTM A 240 stainless steel, grade to match the pipe.
   2. Manufacturing Standard: ASTM A 403, Class WP.
   3. Wall Thickness and Dimensions of Fitting: In accordance with ANSI B16.3 or ANSI B16.9 as appropriate and as required for the schedule of pipe specified.
   4. End Configuration: As needed to comply with specified type of joint.
   5. Forgings conforming to ASTM A182, Grade F304 or Grade F316; or barstock conforming to ASTM A276, Type 304 or Type 316. Forging or barstock material shall match the piping materials.

E. Piping Joints:
   1. Joints in Piping 2 Inches in Diameter and Smaller: Flanged or screwed with Teflon tape thread lubricant, as scheduled per Section 15052.
   2. Welded Joints:
      a. Piping 4 Inches Through 12 Inches in Diameter: Double butt welded joints
c. Each weld shall be marked with a symbol that identifies the welder.

3. Flanged Joints: Conforming to the requirements of ANSI B16.5, Class 150.

4. Piping Stub Ends and Backing Flanges for Pipe 3 inches and Larger:
   a. Piping Stub Ends: Cast Type 304L or 316L stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions. Manufacturers: Alaskan Copper Works, Figure SK-38 or equal.
   b. Backing Flanges: Cast or forged Type 304 stainless steel with drilled bolt patterns conforming to ANSI B16.1, Class 125 or ANSI B16.5, Class 150. Manufacturers: Alaskan Copper Works, Figure SK-39 or equal.

5. Flanges for Schedule 40s and Schedule 80S Pipe:
   a. Provide forged Type 316L stainless steel welding neck flanges or slip-on flanges conforming to ANSI B16.5 Class 150.
   b. Material shall conform to ASTM A182.

F. Gaskets:
   1. All Service Applications: EPDM, nitrile, or other materials compatible with the process fluid.

G. Bolts for Flanges and Stub End/Backing Flanges: In compliance with ASTM A193 heavy hex head. Length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut. Nuts shall comply with ASTM A194 heavy hex pattern.
   1. Bolts and nuts shall be Type 316 stainless steel.

H. Fabrication of Pipe Sections:
   1. Welding: Weld in accordance with Section 05120, except for piping for oxygen and ozone service, and for piping in membrane and reverse osmosis filtration systems.
      a. Oxygen and Ozone Service, Membrane and Reverse Osmosis Filtration Systems: Weld in accordance with ANSI B31.3 using welders qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX as modified by ANSI B31.3.
   2. Weld Seams:
      a. Full penetration welds, free of oxidation, crevices, pits and cracks and without undercuts.
      b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
      c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
      d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

I. Pickling and Passivation:
   1. Following shop fabrication of pipe sections, straight spools, fittings and other piping components, pickle and passivate fabricated pieces.
   2. Passivate in accordance with ASTM A 380 or A 967.
   3. Finish Requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
2.02 STAINLESS STEEL TUBING

A. Stainless Steel Tubing:
   1. Seamless tubing made of Type 316L stainless steel and conforming to ASTM A 269, wall thickness not less than 0.035 inch.

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

C. Valves for Use with Stainless Steel Tubing:
   1. Ball type valves with swage ends to match tubing diameter.
   2. Constructed from:
      a. Type 316 stainless steel with TFE seats.
   3. Manufacturers: Nupro or equal.

2.03 SOURCE QUALITY CONTROL

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

B. Provide written certification that the pipe as supplied conforms to the requirements of ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied conforms to the requirements of ASTM A774. Supplementary testing is not required.

PART 3 EXECUTION

3.01 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings or flanges.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.
3.02 FIELD QUALITY CONTROL

A. Test piping to pressure and by method specified in Piping Schedule.
   1. If pressure testing is accomplished with water, only potable quality water shall be used.
   2. If pressure testing is accomplished with water, piping shall be thoroughly drained and dried.

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

C. Welds in oxygen an ozone service piping shall be examined and inspected in accordance with ANSI B31.3.

3.03 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Handling methods and equipment used shall prevent damage to the coating and shall include the use of wide canvas slings and wide padded skids.
   2. Bare cables, chains, hooks, metal bars, or narrow skids shall not be used.

END OF SECTION
SECTION 15256
CORRUGATED METAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Plain galvanized, bituminous coated, and bituminous coated and paved, galvanized corrugated metal pipe for use in culverts, storm sewers, and other applications.

B. Related Section:
   1. Section 02300 - Earthwork.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M 36 - Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
   2. M 190 - Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.
   3. M 243 - Field Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe Arches and Arches.

PART 2 PRODUCTS

2.01 MATERIALS

A. Corrugated Metal Pipe: In accordance with AASHTO M 36 and M 190.
   1. As an alternative to corrugations specified in AASHTO M 36, provide pipe with corrugations 3 inches from center to center and a depth of not less than 1 inch.

B. Provide pipes, elliptical or round, as well as pipe arches requiring bituminous coating or pavement, with lifting lugs and connecting bands designed to provide positive connection without damaging the coating.

C. Joints:
   1. In addition to joints specified in AASHTO M 36, form 2 rolled annular grooves at ends of each pipe length to receive a rubber gasket.
      a. Bead the joint band to engage the groove most distant from the end of the pipe, and install a circular rubber gasket in the groove nearest the pipe end.

D. Smooth Lined Pipe Type "D":
   1. Where Type "D" CMP is indicated on the Drawings or specified, provide pipe as follows:
      a. Uniformly coated on the outside in accordance with AASHTO Type A pipe.
      b. In addition, pave the pipe on the inside for the entire periphery with bituminous material in accordance with requirements of AASHTO M 190.
c. Apply bituminous paving material in such a manner that a smooth interior will be formed throughout with corrugations filled.

d. Pavement: Minimum thickness of 1/8 inch above the crest of the corrugations.

E. Do not use conventional welding torches for cutting full lined pipe.
   1. Pipe: Saw cut or cut with special cutting tools. Do not use acetylene torch.

F. Whenever possible, shop fabricate connections.

PART 3   EXECUTION

3.01 INSTALLATION

A. Excavation, Bedding, and Backfill: As specified in Section 02300.

B. Provide proper facilities and equipment for lowering sections of pipe into trenches.

C. Protect bituminous coating during installation.

D. Inspect pipe immediately before it is laid, and reject defective pipe and pipe with defective coating.

E. Lay piping to the grades and alignment indicated on the Drawings.
   1. Variation from Prescribed Grade and Alignment: Not to exceed 0.10 foot. Rate of departure from or return to established grade or alignment shall be no more than 1 inch in 10 feet.

F. Install elliptical pipe so that the designated axis, indicated by suitable markings on the top of each end of the pipe sections, coincides with the survey alignment of the trench excavation.

G. Lay corrugated metal pipe and pipe arches with the separate sections joined together in such a manner that the joint space exceeds no more than 1/2 inch, with the outside laps of circumferential joints pointing upstream and with longitudinal laps on the side.

H. Joints:
   1. Before connecting bands are placed around the pipe, coat ends of pipe that will be beneath the band with bituminous mastic or, when of suitable design, fit with circular rubber gaskets to provide a watertight joint.
   2. Coat unprotected metal surfaces with bituminous mastic.
   3. Coat coupling band bolts and damaged areas of the coupling bands and pipe with bituminous mastic as specified hereinbefore prior to placing the backfill.
   4. Tighten coupling bands evenly, keeping equal tension on the bolts.
      a. Where mastic is used, maintain tension until the flow of mastic terminates.
      b. Keep joint uncovered over a period of not less than 1 day.
         1) After this period, before covering the joints, test the nuts for tightness, and where necessary tighten the nuts again.
      c. Where the nut loosens its grip on the bolt, tighten the nut again and leave the joint uncovered until a tight, permanent joint can be obtained.
d. Prior to backfilling around the joint, coat the bolts, lugs, and nuts with bituminous mastic, and fill the annular space between abutting pipe sections with bituminous mastic after assembly of the joint.

I. Ascertain that after backfill and compaction is completed, the vertical diameter of the pipe is not less than the horizontal diameter of the pipe or more than 5 percent greater than the average diameter of the pipe.
   1. When necessary, vertically elongate the larger or more flexible pipes prior to placing the backfill, in order to meet the preceding requirement.
   2. Elongation: Not to exceed 5 percent of the nominal pipe diameter, obtained by deformation of the pipe during manufacturing, by field strutting, by careful control of compaction of bedding material alongside the pipe, or by other means.
      a. Repair damage caused by strutting.

J. Repair and Replacement:
   1. Make field repairs to bituminous coating or paving in accordance with AASHTO M 243.
   2. Where bituminous coating or paving has been damaged to such extent that satisfactory field repairs cannot be made, replace the affected item with a new item.

END OF SECTION
SECTION 15261
REINFORCED CONCRETE LOW-HEAD PRESSURE PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Reinforced concrete low-head pressure pipe, joints, fittings, and specials.

B. Related Sections:
   1. Section 02600 - Reinforced Concrete Pipe (Microtunneling).
   2. Section 09960 - Coatings.
   3. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

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

B. American Society for Testing and Materials (ASTM):
   1. ASTM A 36 - Specification for Carbon Structural Steel.
   3. ASTM C 33 - Specifications for Concrete Aggregates.
   7. ASTM C 361 - Specification for Reinforced Concrete Low-Head Pressure Pipe.

C. American Water Works Association (AWWA):
   2. AWWA C 302 - Reinforced Concrete Pressure Pipe, Noncylinder Type.

1.03 SYSTEM DESCRIPTION

A. Design Requirements: Design pipe and fittings in accordance with ASTM C 361 and the following:
   1. Design Pressure: 25 feet of water.
   2. Earth Load: The cover over the piping plus H-20 loading in accordance with AASHTO standard specifications for highway bridges.
   3. Piping Class: As calculated or as scheduled in Section 15052, whichever is higher.
   4. Design Fittings and Specials: In accordance with AWWA C 302, fabricated
steel piping; reinforced with cement-mortar lining and coating in accordance with AWWA Manual M11 as complemented and modified below.

a. Design Pressure: As specified in Pipe Schedule.

b. Wall Thickness of Steel Fittings and Specials: As calculated, or 3/8 inch, whichever is thicker.

c. Interior Steel Cover: Minimum 1-1/4 inches.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Layout drawings.
   2. Joints.
   3. Fittings and specials.
   5. Structure and pipe connections.
   6. Curing methods.

B. Product Data:
   1. Gaskets.

C. Test results.

D. Design Calculations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete Materials for Pipe Manufacture:
   2. Aggregates: ASTM C 33 except that total deleterious materials shall not exceed 3 percent.

B. Materials for Gaskets: ASTM C 361, O-ring synthetic neoprene rubber gaskets, except as follows:
   1. Tensile Strength: Minimum 1,900 pounds per square inch when tested in accordance with ASTM D 412.
   2. Type A Shore Durometer Hardness: 55 within 3 when tested in accordance with ASTM D 2240.

   2. Durometer Hardness of Gasket: ASTM C 361, except as modified in this Section:
      a. Variation within 3.
      b. Selected hardness incorporated into joint design stress analysis.
      c. Selected hardness compatible with internal working pressure and external pressures from groundwater, and joint type (concrete and/or steel).
      d. For jacked pipe, selected hardness compatible to maintain joint integrity during placement in addition to normal service.

   3. Specific Gravity: Between 1.29 and 1.30 when tested in accordance with ASTM D 297.
   4. Basic Polymer: Minimum 50 percent by volume of neoprene stock.
C. Joints: Neoprene rubber gasket type, capable of sealing joints from either internal or external hydrostatic pressure.
   1. Do not use plastic or fiberglass bell rings or collars.
   2. Do not use flush type joints which utilize embedded steel bell rings and spigots.

D. Fittings and Specials:
   1. Fitting Flanges: AWWA C 207, Class B.
   2. Structure and Pipe Connections:
      a. Concrete Pipe to Steel Pipe or Fittings: Welded steel bell ring of size and shape to fit pipe and fitting ends.
      b. Concrete Pipe to Structure: Steel bell ring cast in structure with gasket for flexible joint as indicated on the Drawings.
      d. Steel Bell Rings: ASTM A 283 or ASTM A 36.
      e. Bell Ring Coating: High solids polyamine epoxy in accordance with Section 09960.
      f. Microtunneling Jacking Pipe: Joint in accordance with Section 02600.

2.02 SOURCE QUALITY CONTROL

A. Perform at least 1 hydrostatic test for each size pipe.

B. Perform at least 1 hydrostatic test on 2 pipes joined together to test a joint. When straight pipe joints are deflected to form curves, test a joint with the maximum deflection.

C. Dye check welds in fittings.

2.03 FABRICATION

A. Manufacture pipe by the centrifugally spun process or by vertical casting between stationary inner and outer metal forms. Do not use packer-head type pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install pipe in accordance with Section 15052 and these Specifications.

B. Laying Pipe: Assemble and join joints in accordance with the manufacturer's published instructions for the type of joint. When assembled, check the position of each rubber gasket with a feeler gauge. Capture neoprene rubber gaskets so gaskets cannot be forced out of intended position because of hydrostatic pressure or forced in when making joints during pipe laying.

C. Installation of Curves:
   1. In general, make horizontal and/or vertical curves using pipe with beveled joints or by slight deflections in the joints of straight pipe.
      a. Do not exceed 5 degrees total angular deflection at a joint for beveled pipe.
      b. Maximum joint opening: Do not exceed 3/4 inch for 36 inch pipe and
smaller, and 1 inch for pipe larger than 36 inch.
2. Where necessary, make short length pipes for curves of shorter radius than can be made with beveled pipe of usual length.

3.02 REPAIR

A. Repair damaged pipe in accordance with ASTM C 361 except use epoxy bonding agent to bond mortar to concrete.

END OF SECTION
SECTION 15281
COPPER WATER TUBE-SEAMLESS, ASTM B 88

PART 1  GENERAL

1.01  SUMMARY

A.  Section includes: Copper water tube-seamless, ASTM B 88.

B.  Related sections:
1.  The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2.  It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
3.  The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
   a.  Section 15061 - Pipe Supports.
   b.  Section 15062 - Preformed Channel Pipe Support System.

1.02  REFERENCES

A.  ASTM International (ASTM):

B.  International Association of Plumbing and Mechanical Officials (IAPMO):
   1.  IS 3 - Installation Standard for Copper Plumbing Tube, Pipe and Fittings.

PART 2  PRODUCTS

2.01 MATERIALS

A.  Seamless copper water tube:
   1.  Type: ASTM B 88:
      a.  Exposed copper piping or tubing: Type L hard-drawn, rigid.
      b.  Copper tubing buried in the ground or in plastic conduit: Type K soft-annealed.
   2.  Fittings: Manufacturers: Solder type forged, or wrought copper. One of the following or equal:
      a.  Hoke, Gyrolok.
      b.  Crawford Fitting Company, Swagelok.
c. Parker.

5. Dielectric insulating unions or fittings: Manufacturers: One of the following or equal:
   b. Watts Series 3001A.
6. Special thread to tube adapters: Manufacturers: One of the following or equal:
   a. Crawford Fitting Company, Swagelok.
   b. Hoke, Gyrolok.
   c. Parker.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Support copper piping and tubing as specified in Sections 15061 and 15062.
   2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
   3. Install copper pipe in accordance with IAPMO IS 3.

B. Installation of copper piping:
   1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.
   2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.

C. Installation of copper tubing:
   1. Install copper tubing in accordance with ASTM B 828 and IAPMO IS 3.
   2. Install copper tubing in straight runs, supported at intervals close enough to avoid sagging.
   3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
      a. Provide a sizing tool to correct distortions.
   4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
   5. Perform flaring with a flare block and yoke type screw feed flaring tool:
      a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
      b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.

3.02 FIELD QUALITY CONTROL

A. Testing: Test copper lines in the same manner as the piping system to which they connect.

END OF SECTION
SECTION 15732
AIR CONDITIONING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Packaged, split system air conditioning units to be used in conjunction with air
terminal units specified in Section 15841.

B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.
   2. Section 01614 - Wind Design Criteria.
   4. Section 01782 - Operating and Maintenance Data.
   5. Section 15050 - Basic Mechanical Materials and Methods.
   6. Section 15841 - Air Terminal Units.
   7. Section 15936 - Heating, Ventilation, and Air Conditioning Controls.
   9. Section 16010 - Electrical Requirements.
  10. Section 16050 - Basic Electrical Materials and Methods.
  11. Section 16062 - Grounding.
  12. Section 16075 - Electrical Identification.
  13. Section 16123 - 600-Volt or Less Wires and Cables.
  14. Section 16133 - Conduits.
  15. Section 16134 - Boxes.
  16. Section 16140 - Wiring Devices.
  17. Section 16144 - Disconnect Switches.
  18. Section 16222 - Motors.

1.02 REFERENCES

A. Air Conditioning and Refrigeration Institute (ARI).

B. American Society of Heating, Refrigerating, and Air Conditioning Engineers
   (ASHRAE):
   1. Standard 52 - Methods of Testing Air-Cleaning Devices Used in General
      Ventilation for Removing Particulate Matter.

C. American National Standards Institute (ANSI):
   1. ANSI/ARI 360, Commercial and Industrial Unitary Air-Conditioning Equipment.

D. Air Movement and Control Association (AMCA).

E. International Conference of Building Officials (ICBO):
   2. Uniform Mechanical Code (UMC).
F. National Electric Code (NEC).

G. National Fire Protection Association (NFPA):
   1. 90A - Installation of Air Conditioning and Ventilating Systems.

H. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. Uniform Plumbing Code (UPC).

I. Underwriters’ Laboratories, Inc. (UL).

J. Title 24 of the California Code of Regulations (Title 24).

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Seismic Supports: Design support to meet criteria as specified in Section 01612.
   2. Wind Supports: For exterior units, design support that meet the criteria as specified in Section 01614.
   3. Electrical Components: UL listed and met the design and installation requirements of the NEC.
   4. Piping, Drains, and Venting: Comply with requirements of the UBC, UMC, UPC, and NFPA 90A.
   5. Motors: Comply with Section 16222.
   7. Unit Air Conditioners: Rated in accordance with ANSI/ARI Standards 210/240 or 360 and ARI 270. Conform to the latest version of ANSI/ASHRAE 15.
   8. Utilize HCFC R-22 as the refrigerant.
   9. For projects located in California, comply with energy efficiency requirements of Title 24.

B. Performance Requirements:
   1. As specified and as listed on the Air Conditioning Unit Schedule at the end of this Section.
   2. Outdoor Noise Levels: Outdoor noise levels in the 8 octave band range as measured in accordance with ARI Standard 270 for split system condensers shall not exceed the following:

<table>
<thead>
<tr>
<th>Unit Nominal Capacity (Tons)</th>
<th>OCTAVE BANDS, hertz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>6</td>
<td>79</td>
</tr>
</tbody>
</table>

   3. Units shall be capable of starting and running at 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of ARI Standard 210/240 or 360.
   4. Cooling Capacities and Energy Efficiency Ratios: Provide units with the minimum following cooling capacities and energy efficiency ratios (EER) as rated in accordance with ARI 210/240 or 360 and 270, unless scheduled otherwise.
<table>
<thead>
<tr>
<th>Nominal Capacity, tons</th>
<th>Net Cooling Cap (Btuh)</th>
<th>EER</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>72,000</td>
<td>10.3</td>
</tr>
</tbody>
</table>

5. Unit Air Flows for Cooling: A minimum of 300 cubic feet per minute per ton but not exceeding 500 cubic feet per minute per ton of cooling unless scheduled otherwise.

6. Air Filters: 25 to 30 percent efficiency when rated in accordance with ASHRAE Standard 52-76.

C. Electrical and Control System Design:
   1. Design and supply necessary electrical power and control systems, thermostats, components, and wiring to make a complete functioning system. Comply with referenced electrical specification sections and design to perform the system cooling only or cooling/heating requirements as specified.
   2. Electrical Power and Control Systems: Comply with the following specification sections:
      a. All of Division 16.
      b. All of Division 17.

1.04 SUBMITTALS

A. Shop Drawings:
   1. System layout, mechanical, electrical power, and control diagrams.
   3. Supports and seismic bracing calculations and details.
   4. Cut sheets on all primary and ancillary equipment.
   5. Proposed cutting and patching.
   6. Maximum recommended equipment vibration levels and field testing method.
   7. Noise levels in 8 octave bands showing compliance with specified levels.
   8. Copy of all factory test results.
   9. For projects located in California, provide certification of compliance with Title 24 energy efficiency standards and approval by the California Energy Commission.

B. Operation and Maintenance Data.

C. Warranties.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. For projects located in California, comply with and be installed in accordance with Title 24.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in one piece, factory assembled, piped, internally wired, charged with refrigerant and compressor oil, and tested.

B. Protect equipment from dust and atmospheric exposure.
   1. Provide temporary closures for equipment openings designed for air flow.
1.07 SITE CONDITIONS
A. As specified in Section 15050.
B. Units shall be capable of starting and operating in ambient temperatures as specified in this Section.

1.08 WARRANTY
A. Special Warranties: From the date of acceptance of the project or date of beneficial use in accordance with Section 15050.
   1. 1-Year Warranty: All components.
   2. 5 Years: For refrigerant compressors and closed or sealed refrigerant systems.
   3. 10 Years: For evaporative and condensing coils.

1.09 MAINTENANCE
A. Extra Materials:
   1. Provide 2 extra sets of filters per unit installed.
   2. Provide 1 extra set of drive belts for each size belt system provided.

PART 2 PRODUCTS
2.01 SPLIT SYSTEM PACKAGED ELECTRIC-COOL AIR CONDITIONING UNITS
A. Manufacturers: One of the following or equal:
   1. Carrier, Air Conditioner Model 38ARZ.
   2. Trane, Air Conditioner Model TTA.

B. Refrigerant Components: Refrigerant circuit including:
   1. Accumulator and filter/drier.
   2. Compressor.
   3. Thermostatic expansion valve.
   5. Flow control valves.
   6. Circuit feed system.
   7. Service gauge connections with gauges on suction, discharge, and liquid lines to charge, evacuate and contain refrigerant.
   8. Insulate refrigerant piping as specified in Section 15082.

C. Compressors:
   1. Fully hermetically sealed, high efficiency, reciprocating or scroll type, with internal and external vibration isolation.
   2. Equipped with high pressure relief.
   3. Equipped with crankcase heater.

D. Condenser Fan:
   1. Propeller type, direct drive, aluminum blades, dynamically balanced, and vertical discharge.
   2. Permanently sealed ball bearings and permanently lubricated.
3. Where the condenser fan is 7.5 hp or larger, provide a variable speed or two speed fan.

E. Condenser Coil: Seamless copper tubes with mechanically bonded aluminum plate fins.

F. Condenser Unit Casing:
   2. Weatherproof design, reinforced, and braced for maximum rigidity.
   3. Provide gasketed removable panels or access doors to service equipment components and connections.
   4. Provide with:
      c. Knockouts for utility and control connections.
      d. Minimum 14 gauge steel roll formed base rail with lifting holes; provide support feet for roof mounting on units under 6 tons size.

G. Controls and Equipment Safety Features:
   1. Provide unit controls for a complete and properly functioning system. Provide, as a minimum, the following:
      a. Condenser fan controls.
      b. Evaporator fan controls with time delay after compressor shutdown.
      c. Motor contactors.
      d. 24 Volt or 120 volt control circuit as scheduled; if 24 volt scheduled, provide control power transformer.
      e. Manually reset circuit breakers.
      f. 5-minute compressor cycle delay.
      g. Check filter switch suitable for field connection remote alarm.
   2. Equipment Safety Features, Include:
      a. High pressure switch.
      b. Compressor overtemperature and overcurrent.
      c. Loss of charge/low pressure switch.
      d. Freeze thermostat on evaporator.
      e. Lock out protection.
   3. HVAC Control System:
      a. Provide contacts and signals to operate unit with the building control system as specified in Section 15936.
      b. Provide unit interface devices and programmable electronic thermostat:
         1) Setpoint range of 60 to 90 degrees Fahrenheit with digital temperature and setpoint indication.
         2) Provide 2 stage cooling when specified unit has 2 stages.
         3) ON-OFF-AUTO air handler fan selector switch.
         4) OFF-COOL unit selector switch or automatic switch over.
         5) 7 day programming schedule with at least 1 set back period per day.
         6) Indicator lights for unit operating mode and unit failure.
         7) Wall mounted with insulated backing plate.
         8) Time delay for compressor restarts and for automatic switch over.
H. Electrical:
1. Unit power and control wiring entering unit cabinet at 1 location.
2. Provide 15 amp, 120 volt, single phase, ground fault interrupter convenience outlet at condenser unit; provide factory installed transformer, and independent fuse or breaker protection for outlet.
3. Provide power disconnect switch at each piece of unit; mount disconnect in NEMA 3R enclosure if exterior to unit.

I. Indoor Air Terminal Unit, When Scheduled Provide:
1. Fan Coil Unit: Fan coil air terminal unit complying with Section 15841; air flow rates and conditions as scheduled on the Air Conditioning Unit Schedule.

J. Motors.
1. Comply with Section 16222 Except as Modified:
   a. Compressor Motors: Cooled by refrigerant gas passing through windings and with line break thermal and current overload protection.

K. Accessories.
1. Hail guard over condenser to protect against damage from hail and other flying debris.
2. Coil guard grill to protect condenser coil from penetration by large objects.
3. Provide condensate drain pipe in accordance with UMC.
4. Provide flexible duct connector on supply and return ducts where connected to air handler or terminal units.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.
   3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
      a. Submit details of proposed cutting and patching.
   4. Confirm specified thermostat or other controls are compatible with specified equipment.

B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.

3.02 PREPARATION

A. Before installation remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings.
3.03 INSTALLATION

A. Observe applicable installation requirements specified in Section 15050.

B. Anchoring and Support:
   1. Provide anchoring and support designed in accordance with current engineering practice for equipment and appurtenances by attaching or connecting to supporting members or by providing other supports.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit air conditioners, controls, and thermostats in accordance with manufacturer's recommendations.
   1. Provide local disconnect switches.

E. Provide flexible duct and flexible piping connections at connections to condensers and air handling unit connections.

F. Upon completion of installation, clean duct, and debris from ductwork, and equipment.

3.04 FACTORY QUALITY CONTROL

A. Completely factory test each unit in cooling modes including economizer operation. Coils and cooling system shall then be evacuated for 30 minutes prior to final charging of unit before shipment.

3.05 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, unit air conditioner vibration within manufacturer's submitted maximum, and that outdoor sound power at levels measured in accordance with manufacturer's submittal recommended procedure does not exceed the specified performance requirements for Outdoor Noise Levels.

B. Test equipment performance and balance equipment in accordance with Section 15954.

3.06 SCHEDULES

A. Air Conditioning Unit Schedule: See attached table for AC Unit Schedule.
## Air Conditioning Unit Schedule

<table>
<thead>
<tr>
<th>Equip. No.</th>
<th>Location</th>
<th>Tons</th>
<th>Fan ESP, &quot;WC&quot;</th>
<th>Inlet DB/WB (°F)</th>
<th>Total/Sensible Capacity (MBH)</th>
<th>Inlet Air DB (°F)</th>
<th>Gas Btu/hr</th>
<th>Volts/Phases/Hz</th>
<th>Unit Power</th>
<th>See Notes at end of Schedule for Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPS-AC-100</td>
<td>Pump Station</td>
<td>6</td>
<td>1.6</td>
<td>90/70</td>
<td>68/68</td>
<td>102</td>
<td>NA</td>
<td>460/3/60</td>
<td>4, 15, 21, 24</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

1. Roof Mounted Single Unit Package
2. Base/floor Mounted Single Unit Package
3. Roof Mounted Condenser Split System
4. Base/floor Mounted Condenser Split System
5. Side Supply Discharge Connection
6. Side Return Connection
7. Bottom Supply Discharge Connection
8. Bottom Return Connection
9. Provide Electric Heating
10. Provide Natural Gas Heating
11. Provide LPG Gas Heating
12. 120 Volt Control Voltage
13. 24 Volt Control Voltage
14. Provide Indoor Air Handling Unit with Direct Drive Fan
15. Provide Indoor Air Handling Unit with Belt Drive Fan and Adjustable Sheaves.
16. Provide duct mounted Fan Coil Unit in accordance with Section 15841 sized for scheduled conditions.
17. Provide Outside Air Manual Damper
18. Provide Economizer
19. Thermostat Provided by Contractor
20. Thermostat Provided by AC Unit Manufacturer
21. Control system specified in Section 15936.
22. Wall mounted unit with self-contained controls.
23. Include service option with return-air smoke detector sensor t be wired in field t shut down unit upon detection of smoke.
24. See air terminal unit, Section 15841, for evaporator details.

END OF SECTION
SECTION 15812
METAL DUCTWORK

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes: Aluminum ductwork.
B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.
   2. Section 15084 - Ductwork Insulation.

1.02 REFERENCES
A. American Society for Testing and Materials (ASTM):
B. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA):

1.03 SYSTEM DESCRIPTION
A. Design Requirements:
   1. Custom design and fabricate metal ductwork for the applications indicated on
      the Drawings and for the conditions specified.
   2. Conform to SMACNA Manual for gauge of sheet metal, joint types, reinforcement,
      bracing, hangers and supports, fabrication, and installation.
      a. Sheet Metal Thicknesses: The greater of that thickness required to
         conform to SMACNA for the design pressure specified and the following
         minimum thicknesses:

         | Diameter or Largest Dimension of Rectangular Duct (Inches) | Minimum Sheet Thickness, Inches (B&S Gauge) |
         |----------------------------------------------------------|------------------------------------------|
         | Up to 12                                                  | 0.025 (22)                               |
         | 13 to 30                                                  | 0.032 (20)                               |
         | Larger than 31                                            | 0.040 (18)                               |

   b. Spacing of Hangers and Supports: Provide supports as indicated on the
      Drawings. When supports are not shown, provide supports as required to
      conform to SMACNA but no greater than the spacing indicated on the
      Drawings or the following requirements; whichever is less:
      1) Ducts 18 Inches and Smaller in Largest Dimension: 8 feet on center.
      2) Ducts over 18 inches in Largest Dimension: 4 feet on center.

   c. Support Connections: Provide as indicated on the Drawings. When not
      indicated on the Drawings, provide in accordance with SMACNA. As a
      minimum, all support connections to metal or wood roofs shall be located
at roof framing members only. No penetrations through roof deck, roof membrane, or connections to roof membrane are acceptable.

3. Design Pressure: 2 inches water column unless otherwise indicated on the Drawings or specified.


5. Hanger Reinforcement:
   a. Ducts 18 Inches and Smaller in Largest Dimension: None.
   b. Ducts over 18 Inches and Under 30 Inches in Largest Dimension: 1-1/2 inches by 1-1/2 inches by 1/8 inch angles, 8 feet on center.
   c. Ducts 30 Inches and Larger in Largest Dimension: 1-1/2 inches by 1-1/2 inches by 1/8 inch angles, 4 feet on center.

6. When ducts are specified with insulation on interior walls, size duct to provide clear inside dimensions indicated on the Drawings.

B. Miscellaneous Design Details:
   1. Changes in Duct Size: Use uniformly tapering sections. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
   2. Bends: With the exception of miter bends, design bends with inside radii equal to duct width or diameter.
      a. Install turning vanes at miter bends.
   3. Duct Sleeves: Install duct sleeve when ducts pass through concrete or masonry walls, slabs, or ceilings.
   4. Access Openings: Install in locations that allow access to dampers, fusible links, controllers, and similar devices.
   5. Flexible Connections: Install at connections to air handling equipment and at locations indicated on the Drawings.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Duct material and details of construction.
   2. System layout including floor and wall penetrations.
   3. Supports and anchoring details.
   4. Other materials and components for duct systems.

B. Product Data: Products and components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Seismic Design Calculations.
   1. Submit stamped design calculations for duct construction and support; the duct support system shall be designed per the SMACNA standards.
   2. The duct support system shall be designed to meet the seismic requirements in specification 01612.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ducts: Aluminum alloy 3003-H14 in accordance with ASTM B 209.

B. Flexible Connectors: 1/4 inch thick neoprene coated sheeting.
C. Turning Vanes: Match duct material.
D. Reinforcing: Formed or extruded aluminum angles.
E. Ductwork Insulation: As specified in Section 15084.

2.02 COMPONENTS

A. Duct Sleeves:
   2. Size: 2 inches larger than the duct or duct with external insulation.

B. Access Openings:
   1. Size: 2 inches less than duct size.
   2. Doors: Gauge not less than duct sheet. Provide continuous hinge and latch on outside.

C. Turning Vanes:
   1. Material: Same as ductwork.
   2. Type:
      a. Single-blade vanes for duct widths less than 36 inches.
      b. Airfoil type vanes for duct widths of 36 inches and greater. No trailing edge.
   4. Provide turning vanes for square-turn elbows and splitters.
   5. Size: 2-inch blades for ducts up to 18 inches, 4-1/2 inch blades for larger ducts.

D. Splitter Dampers: Provide at branch take-offs where necessary for balancing system.

E. Extractors:
   1. Components:
      a. Synchronized steel curved blades.
      b. Heavy side rails.
      c. Screw operator.
   2. Provide extractors at take-off from main supply duct adjacent to diffusers, registers, or grilles where splitter is not used.

2.03 FABRICATION

A. Fabricate ductwork to the configuration and dimensions indicated on the Drawings.
B. Dimensions indicate net free area. Increase duct dimensions by thickness of insulation when internal insulation is specified.
C. Do not utilize S-clips, duct tape, or externally applied mastic on medium pressure duct systems.
D. Do not use snap lock seams.
E. Provide flexible duct connectors at all connections to fans and other air movement equipment.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive metallic ductwork as specified in this Section.
   1. Take measurements and verify dimensions on shop drawings to ascertain fit of installation.
   2. Ascertain that supports and openings are correctly located.

B. Examine and verify structural details and determine conflicts in dimensions and clearances.

3.02 INSTALLATION

A. Before installation remove dust and debris from ducts.

B. Adjust duct alignment where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

C. Install ductwork to provide a system free of buckling, warping, or vibration.

D. Hangers: Install hangers as indicated on the Drawings. When hangers are not detailed, conform to SMACNA System Duct Design and Seismic Restraint Manual standards and the following requirements:
   1. Rectangular Ducts Concealed in Ceiling Spaces:
      a. Use metal strap hangers.
      b. Fasten to sides of duct with 2 screws.
      c. Fasten to bottom of duct with 1 screw.
   2. Rectangular Ducts in Exposed Areas:
      a. Install shelf angle trapeze hangers or Unistrut type hangers.
      b. Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
   3. Round Ducts in Exposed Areas:
      a. Install 2 half-round bands with rods bolted to panels.
      b. Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.

E. Flexible Connections:
   1. Install with collar and metal band to form air-tight joints.
   2. Install with minimum 4 inches of slack in fabric.

F. Provide closed-cell neoprene gaskets at flanged joints.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork under operating conditions. Correct audible leaks and leaks that can be felt with the hand.
B. Test and balance ducting systems as specified in Section 15954.

END OF SECTION
SECTION 15820
DUCTWORK ACCESSORIES

PART 1   GENERAL

1.01   SUMMARY

A. Section Includes:
   1. Dampers and Damper Operators.
   2. Diffusers, Grilles and Registers.
   3. Screens.
   4. Other ductwork accessories.

B. Related Sections:

1.02   DEFINITIONS

A. Dampers, diffusers, grilles, and registers specified are indicated on the Drawings by the abbreviations listed below. Each abbreviation is followed by a hyphen and a number to designate the required style of unit:
   1. DG: Door Grille.
   2. FD: Fire Damper.
   3. RR: Return Register or Grille.
   4. SR: Supply Register, Grille or Diffuser.

B. Return Registers:
   1. RR designation includes wall, ceiling and duct mounted air exhaust or return devices including diffusers and grilles with or without control dampers.
   2. When no return register style is indicated on the Drawings, provide Style RR-4; provide 4 inch flanged drop frame when duct mounting indicated.

C. Supply Registers:
   1. SR designation includes wall, ceiling and duct mounted air supply devices including diffusers and grilles with or without control dampers.
   2. When no supply register style is indicated on the Drawings, provide Style SR-4; provide 4 inch flanged drop frame when duct mounting indicated.

1.03   SUBMITTALS

A. Shop Drawings: Indicate location of duct accessories.

B. Product Data: Manufacturer, model, materials, sizes, pressure drop charts, capacities and included accessories.
PART 2  PRODUCTS

2.01 DIFFUSERS, GRILLES, AND REGISTERS

A. Manufacturers:
   1. Provide diffusers, grilles, and registers manufactured by the same manufacturer.
   2. Diffusers, grilles, and registers: One of the following or equal. One manufacturer's model is listed with each style, similar models from other listed vendors are acceptable:
      a. Titus Manufacturing Corp.
      b. Tuttle and Bailey.
      c. Kees, Inc.
      d. Metal Industries, Inc. (MetalAire).
      e. Krueger.

B. Materials:
   1. For Metallic Ductwork: Aluminum for aluminum duct work; aluminum or galvanized steel for galvanized steel duct work unless specified otherwise with styles.
   2. For Fiberglass Reinforced Plastic Ductwork: Fiberglass reinforced plastic where not otherwise specified.

C. Components: Include specified style with frame, clips, connectors and other accessories necessary for mounting.

D. Appearance: Similar for units in same room or space.

E. Finishes:
   1. In chlorine, hypochlorite or sodium bisulfite storage or pumping rooms and building exhaust systems for these areas: Coat with two 1-1/2 mils thick coats of synthetic vinyl plastic coating suitable for use in gas contaminated exhaust system including chlorine, sulfur dioxide, ozone, or a combination thereof of such gases.
      a. Manufacturers: One of the following or equal:
         1) Bisonite M, Amercoat Number 23 and 55.
         2) Plasite, 2441.
   2. In laboratory room exhaust systems: Coat with two finish coats of synthetic resin over prime applied on clean surface suitable for use in a laboratory exhaust system.
      a. Manufacturers: One of the following or equal:
         1) Carboline Eisen-Heiss.
   3. In other locations, specified factory standard with the style requirements of a color selected by ENGINEER from standard manufacturer's colors.

F. Supply Diffuser, Grille, and Register Styles:
   1. SR-1, Supply Register Style 1:
      a. Size and Installation: 24 inch by 24 inch panel and frame suitable for suspended T-bar lay in ceiling.
      b. Faceplate: Removable, perforated with 3/16 inch holes on 1/4 inch centers.
      c. Core: Adjustable, anti-smudge flow pattern with deflection patterns as indicated on the Drawings and rectangular or round neck to ducting.
d. Damper: Provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.

e. Materials: Aluminum frame, core, damper and face plate.

f. Manufacturers: One of the following or equal:
   1) Krueger, Model 6200/6500 Series.

2. SR-4, Supply Register Style 4:
   a. Size and Installation: Rectangular grille size as indicated on the Drawings framed for surface mounting on gypsum or directly mounted on exposed ducting; provide 4-inch flanged drop frame when duct mounted.
   b. Faceplate: Removable grille with double deflection blades spaced a 3 inch for maximum flow and throw; front blades parallel to long dimension; provide gasket at frame for sealing.
   c. Core: Adjustable vanes with rectangular or round neck to match ducting.
   d. Damper: Provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
   e. Materials: Aluminum frame, core, damper and faceplate.
   f. Manufacturers: One of the following or equal:
      1) Titus, Model PAR-AA.

G. Return Diffuser, Grille, and Register Styles:
1. RR-1, Return Register Style 1:
   a. Size and Installation: 24-inch by 24-inch panel and frame suitable for suspended T-bar lay in ceiling.
   b. Faceplate: Removable, perforated with 3/16 inch holes on 1/4 inch centers matching SR-1 in appearance.
   c. Core: When connected to ducting, provide suitable rectangular or round neck connection to ducting type indicated on the Drawings.
   d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
   e. Materials: Aluminum frame, core, damper and faceplate.
   f. Manufacturers: One of the following or equal:
      1) Titus, Model PAR-AA.

2. RR3, Return Register Style 3:
   a. Size and Installation: Rectangular grille with size as indicated on the Drawings framed for surface mounting on gypsum or directly mounted on exposed ducting; provide 4 inch flanged drop frame when duct mounted.
   b. Faceplate: Removable grille with fixed double deflection blades spaced at 3/4 inch; front blades parallel to long dimension with 35 degree deflection; provide gasket at frame for sealing.
   c. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting; when filter indicated on the Drawings, provide 1 inch deep filter frame and hinged face with 1/4 turn fasteners.
   d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
   e. Materials: Aluminum frame, core, damper and faceplate.
   f. Manufacturers: One of the following or equal:
      1) Titus, Model 350FL or Model 350FF1.

3. RR-4, Return Register Style 4:
a. Size and Installation: Size as indicated on the Drawings suitable for ceiling or side wall surface mounting on gypsum or T-bar ceiling
b. Face: High free area eggcrate with 1/2 inch by 1/2 inch by 1 inch deep grid
c. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting; when filter indicated on the Drawings, provide 1 inch deep filter frame and hinged face.
d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
e. Materials: Aluminum frame, core, damper and face plate.
f. Manufacturers: One of the following or equal:
   1) Titus, Model 50F or 50FF.

H. Door or Partition Grille:
   1. DG-1, Door or Partition Grille Style 1:
      a. Size and Installation: Size as indicated on the Drawings suitable for mounting on wood doors.
      b. Face and Frame: 1.25 inch boarder surface mount boarder with inverted V, site proof blades parallel to the long dimension; countersunk screw holes; provide face plate on both sides of penetration.
      c. Materials: Aluminum frame and blades with baked acrylic finish.
      d. Manufacturers: One of the following or equal:
         1) Titus, Model CT-700-LF.

2.02 SCREENS

A. Characteristics and Features:
   1. Bird Screen: 1/2 inch mesh by 14 gauge.
   2. Insect Screens: 18 by 14 mesh.
   3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
   4. Screens secured in frames.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section. Take measurements and verify dimensions to ascertain fit of installation.

3.02 PREPARATION

A. Before installation remove dust and debris from ducts and accessories.

3.03 INSTALLATION

A. Install items in accordance with manufacturers' instructions.
3.04 FIELD QUALITY CONTROL

A. Set grilles, dampers and diffusers to achieve flows and flow patterns indicated on the Drawings and test finished system as specified in Section 15954.

B. Mark final balance positions on all manual damper actuators with paint pen in a distinctive color.

END OF SECTION
SECTION 15830

FANS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fans, including:
   1. Type 1 - Down-blast centrifugal roof exhausters.
   2. Fire/Smoke Control Systems.

B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.
   2. Section 01614 - Wind Design Criteria.
   4. Section 01782 - Operating and Maintenance Data.
   5. Section 09960 - Coatings.
   6. Section 15050 - Basic Mechanical Materials and Methods.
   7. Section 15852 - Louvers.
   8. Section 15936 - HVAC Controls.
   10. Section 16010 - Electrical Requirements.
   11. Section 16050 - Basic Electrical Materials and Methods.
   12. Section 16062 - Grounding.
   13. Section 16075 - Electrical Identification.
   14. Section 16123 - 600 Volt or Less Wires and Cables.
   15. Section 16133 - Conduit.
   16. Section 16134 - Boxes.
   17. Section 16140 - Wiring Devices.
   18. Section 16144 - Disconnect Switches.
   19. Section 16222 - Motors.

1.02 REFERENCES

A. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

B. American National Standards Institute (ANSI):
   3. ANSI/ABMA 9, Load Ratings and Fatigue Life for Ball Bearings.

C. Air Movement and Control Association (AMCA):
   1. AMCA 211, Certified Rating Program for Air Moving Devices.
   2. AMCA 300, Test Code for Sound Rating.
3. AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

D. American Society for Testing and Materials (ASTM):


F. National Fire Protection Association (NFPA):
   1. 90A - Installation of Air Conditioning and Ventilating Systems.
   2. 820 - Fire Protection in Waste Water Treatment and Collection Facilities.

G. National Roofing Contractors Association (NRCA).

H. International Conference of Building Officials (ICBO):
   2. Uniform Mechanical Code (UMC).

I. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As used in this Section and on the Drawings, abbreviations and Fan Schedule headings have the following meaning:
   1. SF or SPF: Supply Fan.
   2. EF or EXF: Exhaust Fan.
   3. Type: Fan type as specified in this Section.
   4. SP or ESP: Fan External Static Pressure in inches water column.
   5. Size: Nominal fan blade or wheel diameter in inches.
   7. V/Ph: Fan motor Voltage and power Phases.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Provide fans that have sharply rising pressure characteristics which extend throughout the operating range and continue to rise beyond the efficiency peak.
   2. Provide fans that peak as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
   3. When scheduled, provide guided vibration isolator for fans, so that not more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.
   4. Design fan inner scroll and air stream surfaces to maintain smoothness for entire fan service life.
   5. Seismic Supports: Seismic design criteria as specified in Section 01612.
   6. Wind supports for exterior units: Wind design criteria as specified in Section 01614.
7. Electrical Components: UL listed and meeting the design and installation requirements of the NEC.
8. Comply with applicable portions of Section 15050.
9. Motors Supplied with Fans: Manufacturer’s standard when type not scheduled; provide motor voltage phases and speed as scheduled; motor not to be overloaded at any point on the fan curve including belt losses.
10. Roof Curbs: Designed in accordance with NRCA standards.
11. Insulation and adhesives: Meet NFPA 90 A requirements for flame spread and smoke generation.
12. Belt Drive Systems: Adjustable for minimum +/− 5 percent speed change, Rated for 1.5 times maximum horsepower motor available for the scheduled fan size or model.
13. Screens: Provide bird or insect screen as specified with the fan type or as listed on the Fan Schedule:
   a. Bird Screen: Stainless steel; 0.5 inch mesh 18 gauge.
   b. Insect Screen: Stainless steel mesh and frame.
14. Finishes: When not specified with fan type, coat ferrous metals as specified in Section 09960.
15. Accessories: Provide accessories specified and those scheduled.

B. Performance Requirements:
1. Performance requirements are included in the Fan Schedule located at the end of this Section.
2. Fan performance: Rated and licensed to bear the AMCA label in accordance with ANSI/AMCA 210 and AMCA 211.
3. Total sound power levels in the 8 octave band range as measured in accordance with ANSI/AMCA 330, AMCA 301, or AMCA 300 as appropriate for each fan: Not to exceed the lesser of the following or the Sones levels on the Fan Schedule.

<table>
<thead>
<tr>
<th>Frequency, Hz</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1,000</th>
<th>2,000</th>
<th>4,000</th>
<th>8,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Power Level, dBA General</td>
<td>100</td>
<td>98</td>
<td>94</td>
<td>88</td>
<td>84</td>
<td>84</td>
<td>78</td>
<td>75</td>
</tr>
</tbody>
</table>

4. Bearings: Rated per ANSI/ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours; provide greater life when specified with each fan type.

C. Electrical and Control System Design:
1. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system. Design to perform the system ventilating functions with the control systems as specified in Section 15936 or as indicated on the Drawings; and as specified in the following specification sections: Section 16010; Section 16050; Section 16133; Section 16123; Section 16134; Section 16140; Section 16144; Section 16075; Section 16222; Section 16062.

1.05 SUBMITTALS

A. Product Data:
1. Materials.
2. Primary and ancillary equipment.
3. Sound Power Level in each of 8 octave bands and overall Sones.
B. Shop Drawings:
   1. Fan system layout, mechanical, electrical power, and control diagrams.
   2. Supports, vibration isolators, and seismic bracing calculations and details.
   3. Calculated fan vibration levels and field testing method.
   4. Bearing life.
   5. Fan performance curves showing specified operating condition.

C. Seismic Design Calculations.
   1. Submit stamped design calculations for fan support; the fan support shall be
do the SMACNA standards.
   2. The fan support system shall be designed to meet the seismic requirements in
      specification 01612.

D. Factory Test Results.

E. Operation and Maintenance Data.

1.06 QUALITY ASSURANCE

A. Provide Fans:
   1. Listed by UL.
   2. Rated in accordance with AMCA.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in one piece, factory assembled, internally wired, and lubricated.

B. Protect equipment from dust and atmospheric exposure.

C. Provide temporary closures for equipment openings designed for air flow.

1.08 EXTRA MATERIALS

A. Provide 1 extra set of belts per installed fan for fans specified with belt drives.

PART 2 PRODUCTS

2.01 TYPE 4, SIDEWALL PROPELLER FANS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model SBE, SBS, or SBC.
   2. Loren Cook, Models SWF, SWB, SPD, or SPB.
   3. Penn Ventilator, similar model.

B. Characteristics:

C. Type: Wall-mounted, low noise propeller type, packaged unit.
   1. Fan: Statically and dynamically balanced propeller with steel or aluminum
      blades.
   2. Motor: Permanently lubricated; selected to avoid running in the service factor.
D. Accessories:
   1. Motor and fan side OSHA guards.
   2. Wall mount collar when necessary for installation as indicated on the Drawings.
   3. Sampers with damper guards when damper scheduled.
   4. Weather hood when scheduled.
   5. Bird Screen: Provide bird screen if no screen is listed on the Fan Schedule.
   6. Finish: Coat fan, housing and accessories with polyester finish.
   7. Diffusers and louvers when scheduled.
   8. Mounting hardware.

2.02 SOURCE QUALITY CONTROL

A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.

B. Take measurements and verify dimensions to ascertain fit of installation.

C. Ascertain support and openings are correctly located.

3.02 PREPARATION

A. Before installation remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings.

3.03 INSTALLATION

A. Observe applicable installation requirements as specified in Section 15050.

B. Anchoring and Support:
   1. Provide anchoring and support for fans and appurtenances.
   2. Provide anchoring to sustain seismic and wind forces as specified in Sections 01612 and 01614.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit fans and controls in accordance with manufacturer's recommendations.

E. Install flexible connections to fans.

F. Install roof curb and fan as recommended by the fan manufacturer.
G. Construct duct modifications recommended by the fan manufacturer for installation of inline fans.

H. For fan housings with threaded water trap drain, provide drain piped from fan housing to the nearest drain channel, floor drain, or sump.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, and unit vibration is within manufacturer’s submitted maximum.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.05 SCHEDULES

A. Fan Schedule: See Attached.
<table>
<thead>
<tr>
<th>Equip. No.</th>
<th>Location</th>
<th>Type</th>
<th>Drive</th>
<th>Min. CFM</th>
<th>Min. SP'' WC</th>
<th>Design RPM</th>
<th>Fan Diam.</th>
<th>Noise Sones</th>
<th>Hp</th>
<th>V / Ph.</th>
<th>Max. RPM</th>
<th>Additional Requirements (See listed Notes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPS-EF-100</td>
<td>PUMP ROOM</td>
<td>1</td>
<td>BELT</td>
<td>3,050</td>
<td>0.5</td>
<td>820</td>
<td>24''</td>
<td>14</td>
<td>1/4</td>
<td>120/1</td>
<td>1,725</td>
<td>1, 2, 5, 6, 7, 8, 12, 15, 19, 21, 22</td>
</tr>
<tr>
<td>OPS-EF-200</td>
<td>PUMP ROOM</td>
<td>1</td>
<td>BELT</td>
<td>3,050</td>
<td>0.5</td>
<td>820</td>
<td>24''</td>
<td>14</td>
<td>1/4</td>
<td>120/1</td>
<td>1,725</td>
<td>1, 2, 5, 6, 7, 8, 12, 15, 19, 21, 22</td>
</tr>
</tbody>
</table>

Notes:
1. Provide bird screen.
2. Provide insect screen.
3. Provide backdraft damper, counterbalanced for minimum pressure loss.
4. Provide exterior weather hood.
5. Provide adjustable belt sheaves.
6. Provide vibration isolators.
7. Provide manufacturer std. motor enclosure.
8. Provide TEFC motor enclosure and wiring suitable for Class 1, Div. 2 locations.
9. Provide explosion proof motor and wiring suitable for Class 1, Div. 1 locations.
10. Provide variable frequency drive speed controller as specified in this Section.
11. Provide SCR speed controller as specified in this section.
12. Provide exterior disconnect switch at fan, NEMA 3R.
13. Provide NEMA 1 disconnect switch at fan inside housing.
14. Provide 120 volt, line voltage thermostat Type 2 as specified in Section 15936.
15. Provide 24 volt, low voltage thermostat type T-5 as specified in Section 15936.
16. Interlock fan with motorized louver dampers, other fans or equipment as indicated on the Drawings.
17. Provide replaceable filters.
18. Provide motorized backdraft damper.
19. Provide exterior weather louver, Type L-1 as specified in Section 15852.
20. Provide fiberglass canopy hood, size as indicated on the Drawings.
21. Fan selection based on existing opening; field verify opening size and select maximum sized, slowest rpm fan to fit opening and meet performance conditions.
22. Provide fire/smoke control system for all fans greater than 2000 cfm.
SECTION 15841
AIR TERMINAL UNITS

PART 1  GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fan coil units (FCU) to be used in conjunction with air conditioning units specified in Section 15732.

B. Related Sections:
   1. Section 01612 - Seismic Design Criteria.
   2. Section 01614 - Wind Design Criteria.
   4. Section 01782 - Operating and Maintenance Data.
   5. Section 15050 - Basic Mechanical Materials and Methods.
   6. Section 15084 - Ductwork Insulation.
   7. Section 15732 - Air Conditioning Units.
   8. Section 15830 - Fans.
   9. Section 15936 - HVAC Controls.
   10. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.
   11. Section 16010 - Electrical Requirements.
   12. Section 16050 - Basic Electrical Materials and Methods.
   13. Section 16062 - Grounding.
   14. Section 16075 - Electrical Identification.
   15. Section 16123 - Wire and Cables.
   16. Section 16133 - Conduit.
   17. Section 16134 - Boxes.
   18. Section 16140 - Wiring Devices.
   19. Section 16144 - Disconnect Switches.

1.02 REFERENCES

A. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

B. American National Standards Institute (ANSI):
   3. ANSI/ABMA 9, Ball Bearings, Load Ratings and Fatigue Life for.
   5. ANSI/ARI Standard 880 - Air Terminals.
C. Air Movement and Control Association (AMCA):
   1. AMCA 300, Test Code for Sound Rating.
   2. AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

D. American Society for Testing and Materials (ASTM):


F. National Fire Protection Association (NFPA):
   1. 90A - Installation of Air Conditioning and Ventilating Systems.

G. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. Heating Ventilation Air Condition Duct Construction Standards - Metal and Flexible.

1.03 SYSTEM DESCRIPTION

A. General Design Requirements:
   1. Performance and Other Requirements: As scheduled on the Air Terminal Unit Schedule.
   2. Design Pressure: Two inches water column unless otherwise indicated on the Drawings or specified.
   3. Changes in Duct Size to Match Connections: Provide uniformly tapering sections; taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
   4. Access Openings: Provide in locations that allow access to dampers, fusible links, controllers, fans and similar devices.
   5. Supports: Meet SMACNA requirements and seismic design criteria as specified in Section 01612; exterior units to also meet wind design criteria as specified in Section 01614.
   6. Insulation and adhesives: Meet NFPA 90A requirements for flame spread and smoke generation.

B. Additional Design Requirements for Terminal Units with Fans:
   1. Fan performance requirements are included in the Air Terminal Unit Schedule; performance rated in accordance with ANSI/AMCA 210.
   2. Provide fans that have sharply rising pressure characteristics, which extend throughout the operating range and continue to rise beyond the efficiency peak.
   3. When scheduled, provide vibration isolators for fans, so that not more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.
   4. Provide motor type scheduled; when not scheduled provide manufacturer's standard; motors not to be overloaded at any point on the fan curve including belt losses.
   5. Provide motor voltage phases and speed as scheduled.
   6. Provide belt drive systems rated for 1.5 times maximum horsepower motor available for the scheduled fan size or model.
7. When filters scheduled, provide filters with 25 to 30 percent dust spot efficiency when rated per ASHRAE Testing Standard 52.1.
8. Provide bearings rated per ANSI/ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours.

C. Electrical and Control System Design:
   1. Electrical Components: UL listed and meeting the design and installation requirements of the NEC.
   2. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   3. Design to perform the system ventilating functions with the control systems as specified in Section 15936.
   4. Electrical components as specified in the following sections:
      a. Section 16010, Electrical Requirements; Section 16050, Basic Electrical Materials and Methods; Section 16062, Grounding; Section 16075, Electrical Identification; Section 16123, Wire and Cables; Section 16133, Conduit. Section 16134, Boxes; Section 16140, Wiring Devices; Section 16144, Disconnect Switches.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Material and details of construction.
   2. System size, layout and duct connections.
   3. Supports and anchoring details.
   4. Wiring and control diagrams including logic diagrams.

B. Product Data: Products and components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Seismic Design Calculations.
   1. Submit stamped design calculations for air terminal unit support; the support system shall be designed per the SMACNA standards.
   2. The air terminal unit support system shall be designed to meet the seismic requirements in specification 01612.

D. Operation and Maintenance Data.

E. Factory Test Results for Fans.

1.05 QUALITY ASSURANCE

A. Provide Fans:
   1. Listed by UL.
   2. Rated in accordance with AMCA.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in one piece, factory assembled, internally wired, and lubricated.

B. Protect equipment from dust and atmospheric exposure.
C. Provide temporary closures for equipment openings designed for airflow.

1.07 WARRANTY

A. Special Warranties: From the date of acceptance of the project or date of beneficial use:
   1. One-year warranty: All components.
   2. 10 years: For coils.

1.08 EXTRA MATERIALS

A. Provide 2 extra sets (3 sets total) of filters per installed fan unit for fan units specified with filters.

PART 2 PRODUCTS

2.01 FAN COIL UNITS (FCU)

A. Manufacturers: One of the following or equal:
   1. Fan:
      a. Greenheck, Model BSQ.
      b. Similar product by Arrow.
   2. Coil:
      a. Carrier Model 40RM.
      b. Trane, equivalent model.

B. Components and Requirements:
   1. Type unit: Assembled unit consisting of an in-line centrifugal fan and an air coil unit.
   2. Size and Performance: Air flows and pressures as scheduled; connecting duct sizes as indicated on the Drawings.
   3. Installation: Provide supports suitable for attachment to the ceiling or roof underside indicated on the Drawings.
   4. Fan Characteristics:
      a. In-line centrifugal type with backward-inclined non-overloading wheels.
      b. Tubular or square type housing with duct transitions to match fan supplied.
      c. Motor mounted underneath fan and on exterior of housing.
      d. Balance the fan wheel both statically and dynamically.
   5. Fan Accessories:
      a. External junction box for field connection of electrical wires.
      b. Counterbalanced backdraft damper on exhaust side of fan when backdraft damper scheduled.
      c. When variable speed fan controlled scheduled, provide controller as specified in this Section.
   6. Fan Materials:
      a. Casing: Galvanized steel or aluminum, minimum 10 gauge.
      b. Mounting Base: Galvanized steel or aluminum.
      c. Blades: Aluminum.
      d. Fasteners: Stainless steel.
7. Coils:
   a. Materials: Copper with aluminum fins.
   b. Performance: As scheduled herein and in Section 15732.
      1) Coils shall be compatible with the condensing units specified in Section 15732.
      2) Coils shall be designed to conform to the ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a refrigerant pressure not exceeding 250 psig and shall be tested with 300 PSIG compressed air under water.
      3) The completed DX coil, including headers, return bends and distributors shall be charged with clean nitrogen and sealed for shipment.
      4) Each coil shall be furnished with a brass distributor with solder-type connections.
      5) Suction and discharge connections shall be on the same end regardless of rows deep.
   c. Drain Pan: For cooling coils, provide aluminum condensate pan and PVC drain line.
   d. Ducting Slope: Slope ducting at 0.25 inch per foot for minimum of 10 feet downstream of cooling coils; slope back to drain pan.
   e. Provide piping insulation for refrigerant piping.

PART 3 EXECUTION

3.01 EXAMINATION

   A. Examine and verify that Work is in condition to receive units into ductwork as specified.
      1. Take measurements and verify dimensions on shop drawings to ascertain fit of installation.
      2. Ascertain that supports and openings are correctly located.

   B. Examine and verify structural details and determine conflicts in dimensions and clearances.

3.02 INSTALLATION

   A. Before installation, remove dust and debris from ducts.

   B. Adjust duct alignment where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

   C. Install units in ductwork to provide a system free of buckling, warping, or vibration.

   D. Hangers: Install hangers as indicated on the Drawings. When hangers are not detailed, conform to the following requirements:
      1. Rectangular Ducts Concealed in Ceiling Spaces:
         a. Use metal straphangers.
         b. Fasten to sides of duct with 2 screws.
         c. Fasten to bottom of duct with 1 screw.
2. Rectangular Ducts in Exposed Areas:
   a. Install shelf angle trapeze hangers or Unistrut type hangers.
   b. Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.

3. Round Ducts in Exposed Areas:
   a. Install 2 half-round bands with rods bolted to panels.
   b. Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.

E. Flexible Connections:
   1. Provide at units with fans and install with collar and metal band to form airtight joints.
   2. Install with minimum 4 inches of slack in fabric.

F. Provide closed-cell neoprene gaskets at flanged joints and for all connections between dissimilar materials.

3.03 FIELD QUALITY CONTROL

A. Inspect units and ductwork under operating conditions. Correct audible leaks and leaks that can be felt with the hand.

B. Test and balance ducting systems as specified in Section 15954.

3.04 ATTACHMENTS

A. Air Terminal Unit Schedule.
## AIR TERMINAL UNIT SCHEDULE

<table>
<thead>
<tr>
<th>Equip. No.</th>
<th>Location</th>
<th>Total Unit Air Flow</th>
<th>Evaporator Cooling Capacity</th>
<th>Fan</th>
<th>Fan Motor</th>
<th>Additional Requirements (see Notes at end of Schedule)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maximum CFM</td>
<td>Minimum Sensible/ Total Capacity MBH</td>
<td>Inlet DB/ WB (°F)</td>
<td>Outlet DB/ WB (°F)</td>
<td>Supply Air Flow, CFM</td>
</tr>
<tr>
<td>OPS-FC-100</td>
<td>Elec. Room</td>
<td>3,000</td>
<td>DX</td>
<td>68/68</td>
<td>90/66</td>
<td>55/51</td>
</tr>
</tbody>
</table>

### Schedule Abbreviations:
- cfm - Cubic feet per minute of standard air
- DX - Direct expansion coil
- HW - Hot water coil
- CW - Cold or chilled water coil
- MBH - Thousands of Btu per hour
- V - Supply power voltage (at 60 Hz)
- Ph. - Supply power phases

### General Requirements for all units:
- Motor rpm to be 1800 rpm or less

### Additional Requirement Notes:
1. Provide electric damper operator.
2. Provide pneumatic damper operator and controller.
3. Provide electric damper actuator and controller suitable for use with control system specified in Section 15936.
4. Provide 120-volt thermostat with compatible damper controller.
5. Provide low voltage thermostat with compatible electronic damper controller.
6. Provide direct drive fan.
7. Provide belt drive fan with adjustable belt sheaves.
8. For FPU units, minimum and maximum air rates are for primary air flow or combined primary and secondary air flow; maximum secondary air (fan) flow is scheduled under fan cfm.
9. Provide speed controller, VFD or SCR type with digital or electronic controller as specified in Section 15930 compatible with building control system as specified in Section 15936.
10. Aluminum materials of construction.
12. Provide 2-inch deep filter box with filters on units connected to an outside air intake.
13. Provide insect screen on air intake at roof or wall.

---

END OF SECTION
SECTION 15852
LOUVERS

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Stationary Weather Louvers.
   2. Sightproof Stationary Louvers.
   3. Acoustical Louvers.
   4. Penthouse Louvers.
B. Related Sections:
   1. Section 15954 - Discharge Duct Silencer.
   2. Section 15954 - HVAC Testing, Adjusting, and Balancing.

1.02 REFERENCES
A. Air Movement and Control Association (AMCA):
   1. 500 - Test Methods for Louvers, Dampers, and Shutters.

1.03 PERFORMANCE REQUIREMENTS
A. Performance: Meet requirements when tested in accordance with AMCA 500.
B. Designed for 20 pounds per square foot wind load.

1.04 SUBMITTALS
A. Shop Drawings: Include dimensions, anchorage details, and relationships to adjacent materials.
B. Product data.

1.05 QUALITY ASSURANCE
A. Provide louvers with the following, unless otherwise specified:
   1. AMCA certification and rating in accordance with AMCA 500 for air performance and water penetration.

PART 2 PRODUCTS

2.01 GENERAL
A. Louver Types: Louvers are marked on the Drawings with a letter L followed by a number referring to a louver type in this Section. Individual louver size and airflow rates are as indicated on the Drawings.
B. Accessories:
   1. Provide installation clips and flanged or jamb-mounting styles suitable for the mounting locations as indicated on the Drawings.
   2. Provide extended sills for louvers indicated as installed recessed from the exterior wall surface.
3. Provide stainless steel fasteners unless noted otherwise.
4. Corrosion Protection:

C. Protective Coatings for Aluminum in Contact with Concrete or Masonry:
   1. Manufacturers: One of the following or equal:
   2. Koppers Company, Inc.
   3. Tarmastic 100.
   4. Porter Coatings.

2.02 STATIONARY WEATHER LOUVERS, TYPE L-1

A. Manufacturers: One of the following or equal:
   1. Ruskin, Model ELF 6375DXH.
   2. Airolite Company, equivalent product.

B. Requirements:
   1. Type: Stationary louver with drainable blades.
   2. Frame: 6-inch deep, minimum 0.125 inch thick, Type 6063-T5 aluminum with
donspouts and caulking channel provided.
   3. Blades: Minimum 0.125 inch thick, Type 6063-T5 aluminum drainable blades,
      stationary mounted at 37.5 degrees and spaced at 6-in.
   4. Blade Supports: if required shall be made from type 6063-T5 extruded
      aluminum and shall have minimum depth.
   5. Screens: Removable 1/2-inch deep aluminum frame with aluminum wire.
      Intake louvers shall be provided with insect screens and exhaust louvers with
      bird screens. Minimum size openings for bird screens shall be 1/4-inch.
   6. Pressure Drop (without screen): Maximum 0.15 inches water column for
      exhaust service and 0.12 inches water column for intake service at 1,000 feet
      per minute free area velocity.
   7. Water Penetration: Maximum 0.01 ounce water per square foot at 1,000 feet
      per minute free area velocity.
   8. Free Area: Minimum 57 percent.
   10. Finish: Mill finish with color as shown on Drawings.

2.03 STATIONARY ACOUSTICAL LOUVERS, TYPE L-2

A. Manufacturers: One of the following or equal:
   2. Airolite Co., equivalent model.
   3. Industrial Acoustics Co., equivalent model.

B. Requirements:
   1. Type: Stationary acoustical louver.
   2. Frame: 6-inch deep type 6063-T5, extruded aluminum frame with 0.125-inch
      nominal wall thickness.
   3. Blades: exterior surface blades shall be made from minimum 0.081-inch thick
      type 6063-T5, extruded aluminum with minimum 0.040-inch thick perforated
      aluminum interior surface blades. Sound insulation placed between the blade
      surfaces shall be minimum 1-inch thick fiberglass. Blades shall be positioned
      at a 45-degree angle and spaced approximately 4 5/8-inch center-to-center
      distances.
4. Blade Supports: if required shall be made from type 6063-T5 extruded aluminum and shall have minimum depth.
5. Screens: 1/4-inch openings by 0.051-inch flattened aluminum or stainless steel bird screen with removable frame.
6. Pressure Drop: Maximum 0.1 inches water column pressure drop at 1,000 feet per minute free area velocity for intake louvers.
7. Water Penetration: Maximum 0.01 ounce water per square foot at 1,000 feet per minute free area velocity.
8. Free Area: Minimum 30 percent.
9. Finish: Mill finish with color as shown on Drawings.
10. Acoustical Performance: Attenuation at least as follows for the depth of louver indicated:

<table>
<thead>
<tr>
<th>Frequency (Hertz)</th>
<th>Attenuation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>9</td>
</tr>
<tr>
<td>125</td>
<td>7</td>
</tr>
<tr>
<td>250</td>
<td>8</td>
</tr>
<tr>
<td>500</td>
<td>9</td>
</tr>
<tr>
<td>1,000</td>
<td>10</td>
</tr>
<tr>
<td>2,000</td>
<td>16</td>
</tr>
<tr>
<td>4,000</td>
<td>16</td>
</tr>
<tr>
<td>8,000</td>
<td>19</td>
</tr>
</tbody>
</table>

PART 3 EXECUTION

3.01 INSTALLATION

A. Install louvers in accordance with manufacturer's instructions; caulk all frames to make weather tight.

B. Louvers installed in openings for equipment installation, removal, or maintenance shall be designed for field removal and re-installation without louver projections on floors or walls.

C. Anchor louvers to concrete or masonry with concrete anchors through jambs.

D. Corrosion Protection:
   1. Aluminum in Contact with Concrete or Masonry: Apply 2 coats bitumastic black solution.
   2. Aluminum in Contact with Dissimilar Metal, Except Stainless Steel: Isolate from dissimilar metal with neoprene gaskets, sleeves or washers. Utilize stainless steel fasteners.
   3. Field Testing: As specified in Section 15954.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Controls for Heating, Ventilating and Air Conditioning (HVAC) Systems:
   1. Thermostats.
   2. Air flow switches.
   3. Duct mounted smoke detectors.
   4. HVAC control descriptions

B. Related Sections:
   1. Section 01782 - Operating and Maintenance Data.
   2. Section 13411 - Control Strategies.
   3. Section 15050 - Basic Mechanical Materials and Methods.
   4. Section 15812 - Metal Ductwork.
   5. Section 15732 - Air Conditioning Units.
   6. Section 15830 - Fans.
   7. Section 15841 - Air Terminal Units.
   8. Section 15954 - HVAC Testing, Adjusting, and Balancing.
   9. Section 16123 - 600 Volt or Less Wires and Cables.
   10. Section 16133 - Conduits.

1.02 REFERENCES

A. National Electric Code (NEC).
B. National Fire Protection Association (NFPA).
C. Underwriters’ Laboratories, Inc. (UL).
D. Title 24 of California Code of Regulations (Title 24).

1.03 SYSTEM DESCRIPTION

A. General Requirements:
   1. All electrical components shall be UL listed and meet the design and installation requirements of the NEC.
   2. Complete, Functional System: Provide all necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   3. Comply with electrical specifications in Related Sections for electrical power and control systems.
   4. System control functions to perform as described in Part 2.
   6. Common Manufacturer: Provide components, component accessories, and devices, as much as possible, by the same manufacturer throughout the work.
7. Mounting: Mount control components and devices in accessible locations for maintenance and as recommended by the manufacturer; provide necessary manufacturer approved mounting and configuration hardware for mounting and operation of control components and devices.

8. Components and systems must comply with Title 24 energy conservation regulations and be listed with the California Energy Commission as approved for sale in California.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's Information Including:
      a. Catalog information clearly marked to show specific products, models and sizes being furnished.
      b. Component cut sheets.
   2. Control diagrams showing the interconnection of control components including wiring terminal strip diagrams.
   3. Detail drawings showing control panel layout and dimensions including control panel terminal strips for wiring to outside control devices and panels.
   4. Provide certification that components and systems meet California Title 24 requirements and are approved by the California Energy Commission.

B. Operations and Maintenance Data per Section 01782.

1.05 QUALITY ASSURANCE

A. The control system shall be designed to conform to UL and CSA standards.

B. Regulatory Requirements: Comply with Title 24 of the California Code of Regulations.

1.06 DELIVERY, STORAGE, AND HANDLING

A. The system control products shall be stored and handled per manufacturer's recommendations.

1.07 SITE CONDITIONS

A. Elevation and ambient conditions as specified in Section 15050.

1.08 WARRANTY

A. Special Warranties: Warranty period begins at date of Project Acceptance or first date of Beneficial Use by the OWNER:
   1. 1 Year: Parts and on-site labor for components, systems and programming.
PART 2 PRODUCTS

2.01 THERMOSTATS

A. General:
   1. Thermostat Types: Thermostat types are called out on the Drawings by the letter T followed by a number; this designation refers to the specified thermostat types given in this Section; where no type is called out, provide one of the specified types that will match the controlled equipment requirements and provide a functioning system.
   2. Manufacturers: One of the following or equal:
      a. Johnson Controls, model as specified with each type.
      b. Honeywell, Tradeline, equivalent models.

B. T-2, Type 2 Thermostat, Cooling Only, Line Voltage:
   1. Johnson Controls Model:
      a. Dry Locations (no hose bibs or open water processes in room): Model A19BBC-2 in NEMA 1 enclosure.
      b. Wet Locations (hose bibs or open water processes in room): Model A19KNC-1 in rain and dust tight enclosure.
   2. Switch Action: Single pole double throw, close on rising temperature.
   4. Setpoint: 30 to 110 degrees Fahrenheit. with knob adjuster and visible scale.
   5. Electrical Ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.
   6. Differential Range: For dry locations, 3 to 12 degrees F adjustable; for wet locations, 5 degrees F fixed.

2.02 DUCT-MOUNTED SMOKE DETECTORS

A. Manufacturers: The following or equal:
   2. Simplex.

B. General:
   1. Provide duct-mounted smoke detectors downstream of fans and ahead of branch connections in air supply ducting with flows greater than 2,000 cubic feet per minute whether or not smoke detectors are indicated on the Drawings.
   2. Smoke detectors shall be UL listed for use in air distribution systems and shall comply with NFPA 90A.
   3. Connect the smoke detector to:
      a. Building fire alarm system.
      b. Fan control circuit to shut down supply fan upon detection of smoke.
      c. Damper control circuits to close supply air dampers to prevent spread of smoke.

C. Characteristics:
   1. Addressable duct sensor housing.
   2. Ionization type with replaceable ionization sensor head.
   3. Operating temperature range of 32 degrees Fahrenheit to 150 degrees F.
   4. Operate at air flow velocities of 500 to 4,000 feet per minute.
   5. 24 VDC power is supplied by fire alarm system.
   6. Capable of mounting to rectangular or round ducts.
7. Integral filter to reduce dust.

D. Accessories:
1. Provide metal sampling tube and end cap to match duct width.
2. Provide mounting base and hardware.
3. Provide duct access door per Section 15812. Provide similar for nonmetallic ducting.
4. Provide a 30 VDC 10 amp DPDT auxiliary contact.
5. Provide remote annunciator with alarm and power LEDs.
6. Provide remote test station.

E. Installation:
1. Install as indicated on the Drawings, per NFPA 90A, and per the manufacturers written instructions.
2. Provide all electrical work to support smoke detector. Coordinate with electrical subcontractor.
3. Mount remote annunciator and test station on wall near smoke detector. Devices shall be easily accessible from floor level.

2.03 HVAC CONTROL DESCRIPTIONS

A. General: Provide control systems that will maintain room or area comfort under changing ambient conditions and varying use; descriptions in this Section are general in nature and do not cover every mode of operation.

B. Coordinate HVAC equipment operation with P&ID drawings and Specification Section 13411. Provide air flow monitoring and alarm controls as described for all fans. Provide fan interlocks and shut down requirements as described. Provide emergency shut off switch outside of each exit as required by the UBC and UFC and as shown on the electrical drawings.

C. HVAC Control Description:
1. Controls at equipment:
   a. Control shall be as described in equipment specifications.
   b. Provide alarm controls as described for all fans.
   c. Provide disconnect switches for all fans.
2. Zone Controls:
   a. Electrical Room:
      1) Air conditioners OPS-FC-100 and OPS-AC-100 shall be controlled by a thermostat with a summer setpoint temperature of 90 degrees F.

2.04 ELECTRICAL

A. All conduits and conductors not shown on the electrical drawings but required for system operation shall be provided under Division 16. This shall include conduits, switches, boxes and conductors to all dampers, motors, differential pressure switches, control valves, controllers, interlocks, alarms, connection to fire alarm control panel, and 120V fans connected through HVAC panels. All electrical equipment shall conform to the requirements specified in Division 16.
PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.

B. Take measurements and verify dimensions to ascertain fit of installation.

C. Ascertain structural sufficiency to support installation.

D. Ascertain that supports and openings are correctly located; cut new openings where required.
   1. Submit details of proposed cutting and patching.

3.02 PREPARATION

A. Before installation remove dust and debris from equipment and accessories.

B. During installation and until equipment is operated, protect equipment, and accessories from dust and debris.

3.03 INSTALLATION

A. Comply with manufacturers' installation requirements.

B. Coordinate installation of HVAC control systems with other trades. Prior to installation, coordinate wiring and conduit requirements with electrical subcontractor.

C. Sensor and Control Station Mounting:
   1. Where not otherwise indicated, mount 5 feet above floor or walking level.
   2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
   3. Shield outside thermostats or sensors from the sun; provide thermostats with remote bulb and compensated capillary.
   4. Install locking covers where indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Test each control system and provide written, signed and dated test report.
   1. Test individual control components and accessories to ensure compliance with the specifications
   2. Test functions of each control system as a complete system to ensure compliance with the specifications.

B. Test each control components and systems as part of HVAC system testing, adjusting, and balancing as specified in Section 15954.

END OF SECTION
SECTION 15954

HVAC SYSTEMS TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Heating, ventilation, and air conditioning systems testing, adjusting, and balancing.

B. Related Sections:

1.02 REFERENCES

A. Associated Air Balance Council (AABC):

B. National Environmental Balancing Bureau (NEBB):

C. Sheet Metal and Air Conditioning Contractors' National Association, Incorporated (SMACNA):

1.03 TESTING, ADJUSTING, AND BALANCING WORK REQUIREMENTS

A. Procure the services of an independent air balance and testing agency belonging to and in good standing with the Associated Air Balance Council or the National Environmental Balancing Bureau to perform air and hydronic balancing, testing, and adjustment of building and process air conditioning, heating, and ventilating air systems.

B. The Work Includes: Balancing new air and hydronic systems installed as part of this contract and existing air and hydronic systems affected by the installation of new equipment.

C. Perform testing of heating, ventilating, and air conditioning equipment, balancing of distribution systems, and adjusting of air terminal units and ductwork accessories to ensure compliance with Specifications and Drawings. Perform Tests for Following:
   1. Air conditioning units.
   2. Fans.
   3. Air terminal units.
   4. Ductwork accessories.
   5. Ducting.
   6. HVAC controls.
D. Test each mode of operation of thermostats, electronic controllers, and pneumatic, electric or electronic heating, ventilating, and air conditioning instruments to ensure operation as specified.

E. Test and adjust room distribution patterns at air outlets.

F. Provide instruments required for testing, adjusting, and balancing operations; retain possession of instruments; remove instruments from site at completion of services.

G. Make instruments available to the ENGINEER to facilitate spot checks during testing.

H. Provide test holes for pressure and pitot flow measurements; provide plugs for all test holes after testing.

1.04 QUALITY ASSURANCE

A. Test, balance, and adjust environmental systems in accordance with either:

B. Perform services under direction of AABC or NEBB certified supervisor.

C. Calibrate and maintain instruments in accordance with requirements of standards. Make calibration histories of instruments available for examination.

D. Make measurements in accordance with accuracy requirements of standards.

E. Testing, Adjusting, and Balancing Performance Requirements:
   1. Comply with procedural standards of certifying association.
   2. Execute each step of prescribed testing, balancing, and adjusting procedures without omission.
   3. Accurately record required data.
   4. Make measurements in accordance with recognized procedures and practices of certifying association.
   5. Measure air volume discharged at each outlet and adjust air outlets to design air volumes within 5 percent over.

1.05 SUBMITTALS

A. Resumes of proposed supervisor and personnel showing training and qualifications.

B. Interim Reports: At least 30 days prior to starting field work, submit the following:
   1. Set of report forms filled out as to design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.
   2. Develop heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
   3. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
      a. Manufacturer and model number.
      b. Description and use when needed to further identify instrument.
c. Size or capacity range.
d. Latest calibration date.

C. Final Report: At least 15 days prior to CONTRACTOR’s request for final inspection, submit 3 copies of final reports, on applicable reporting forms. Include:
1. Identify instruments which were used and last date of calibration of each.
2. Procedures followed to perform testing, adjusting, and balancing.
3. Identification and succinct description of systems included in report.
4. Initial balance test results made with all dampers and air control devices in full open positions.
5. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
6. Description of final location and opening positions of dampers, registers, louvers, and valves.
7. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
8. Testing, adjusting, and balancing report forms.
9. Final field results established for system balancing including air flow, fan speeds and fan static pressures at the fan inlet and outlet.
10. Appendices.
11. Include Appendices For:
   a. Raw field data taken during testing.
   b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
   c. Initial air balance results with dampers and registers in full open position; include air flow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

D. Proposed schedule for testing and balancing.

E. Certificate of proper installation. Comply with Section 01756.

1.06 SITE CONDITIONS

A. Prior to start of testing, adjusting, and balancing, verify that:
1. Systems installation is complete and in full operation.
2. Outside conditions are within reasonable range relative to design conditions.
3. Lighting fixtures are energized.
4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each systems which require testing.

PART 2 PRODUCTS

Not Used.
PART 3  EXECUTION

3.01  FIELD QUALITY CONTROL

A. Testing, Adjusting, and Balancing Acceptance Criteria: Consider testing, adjusting, and balancing procedures successful and complete when heating, ventilating and air conditioning systems and components are functioning properly and system air and water flows are within specified tolerances of design flows.

3.02  TESTING, ADJUSTING, AND BALANCING

A. Test, adjust, and balance separate complete heating, ventilating, and air conditioning systems.

B. Include in testing, adjusting, and balancing related existing heating, ventilating and air conditioning components.

C. Perform testing, adjusting, and balancing cycles until air flows meet acceptance criteria.
   1. Ascertain air flow balance between overall requirements and flow in individual supply and exhaust grills.

D. Initial Testing, Adjusting, and Balancing: Perform first test on each system with dampers, grills, orifices, and other variable air flow devices in their full open position; measure and report initial air flows, fan speed and fan static pressures at fan inlet and outlet.
   1. Adjust total system flow downward or upward by adjusting fan speed until 1 inlet or outlet is at indicated flow and all other flows exceed indicated flows.
   2. Adjust fan speed by changing fan drives or sheaves as necessary.

E. Subsequent Testing, Adjusting, and Balancing: Perform adjustments in subsequent testing, adjusting, and balancing by adjusting dampers, louvers, or size of orifices or plates.
   1. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
   2. Adjust fan speeds and motor drives within drive limitations, for required air volume.
   3. Measure cfm and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
   4. Measure and record static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
   5. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
   6. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
   7. Permanently mark final balance positions of balancing dampers.

F. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.

G. Accurately record the required data on Associated Air Balance Council or National Environmental Balancing Bureau test and balance report forms.
H. Measure amperage draw of fan and pump motors for final balance.

I. Test primary source equipment in accordance with AABC or NEBB procedures.
   1. Primary source equipment includes items listed in Part 1 not previously tested as part of this testing, adjusting, and balancing work.
   2. Complete appropriate AABC or NEBB equipment test forms for each piece of equipment.
   3. Calculate cooling and heating capacities to show conformance with specified capacities.
   4. Adjust equipment as needed to deliver specified cooling and heating loads.
   5. Record final equipment performing characteristics and adjustment settings in the final design report.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Test requirements for piping system.

B. Related Sections:
   1. Section 01500 - Temporary Facilities and Controls.
   2. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

A. Uniform Plumbing Code (UPC).

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

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

D. Uniform Mechanical Code (UMC).

1.03 TESTING REQUIREMENTS

A. General Requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in
      the Piping Schedule in Section 15052; are specified in the specifications
      covering the various types of piping; and are specified herein.
   2. Requirements in Laws and Regulations supersede other requirements of
      Contract Documents, except where requirements of Contract Documents are
      more stringent, including higher test pressures, longer test times, and lower
      leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the Uniform
      Plumbing Code, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the
      pressure at the highest point of the piping section under test. Lower test
      pressure as necessary to prevent testing the lowest point above a safe test
      pressure.

B. Furnish necessary personnel, materials, and equipment, including bulkheads,
   restraints, anchors, temporary connections, pumps, water, pressure gauges, and
   other means and facilities required to perform tests.
C. Water for Testing, Cleaning, and Disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in
      Section 01500.

D. Pipes to be Tested: Test only those portions of pipes that have been installed as
   part of this Contract. Test new pipe sections prior to making final connections to
   existing piping. Furnish and install test plugs, bulkheads, and restraints required to
   isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful Tests:
   1. Where tests are not successful, correct defects or remove defective piping and
      appurtenances and install piping and appurtenances that comply with the
      specified requirements.
   2. Repeat testing until tests are successful.

F. Test Water Disposal: Dispose of testing water into TID Lateral No. 5 in accordance
   with requirements of federal, state, county, and city regulations governing disposal
   of wastes in the location of the Project and disposal site.

1.04 SUBMITTALS

A. Schedule and Notification of Tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding
      the date of the scheduled tests.
   2. Notification of Readiness to Test: Immediately before testing, notify
      ENGINEER in writing of readiness, not just intention, to test piping. Have
      personnel, materials, and equipment specified in place before submitting
      notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before
   backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not
   indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement
   before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with
   slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.
PART 3  EXECUTION

3.01  TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and Grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

3.02  AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.
B. Test air piping by the air test method.
C. Test at pressure as specified in Piping Schedule in Section 15052.
   1. Provide temporary pressure relief valve for piping under test. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ANSI/ASME B31.1, ANSI/ASME B31.3, ANSI/ASE B31.8, or the pipe manufacturer’s stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of one-half the test pressure or 25 pounds per square inch gauge.
   4. Perform initial check of joints and fittings for leakage.
   5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
   6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
   7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03  TESTING GRAVITY FLOW PIPING

A. Test Gravity Flow Piping Indicated with "GR" in the Piping Schedule, as Follows:
   1. Unless Specified Otherwise, Subject Gravity Flow Piping to the Following Tests:
      a. Alignment and grade.
      b. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
   3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours.
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.

c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of four hours while accurately measuring the volume of water added to maintain the test pressure.

1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:

a) For Concrete Piping with Rubber Gasket Joints: 80 gallons per day per inch of diameter per mile of piping under test.

(1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping schedule.

B. General:

1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.

2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.

3. Do not include valves, equipment or piping specialties in test sections if test pressure exceeds the valve, equipment or piping specialty safe test pressure allowed by the item's manufacturer.

4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.

5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.

6. When Test Results Indicate Failure of Selected Sections, Limit Tests to Piping:

a. Between valves.

b. Between a valve and the end of the piping.

c. Less than 500 feet long.

7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing Procedures:

1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.

2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.

3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.
D. Pressure Test with Maximum Leakage Allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
      c. When leakage is allowed, calculate the allowable leakage by the following formula:

\[
L = S \times D \times P^{1/2} \times 133,200^{-1}
\]

wherein the terms shall mean:

- **L** = Allowable leakage in gallons per hour.
- **S** = Length of the test section in feet.
- **D** = Nominal diameter of the piping in inches.
- **P** = Average observed test pressure in pounds per square inches, gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.
- **x** = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible Leaks Test:
   1. Subject piping under test to the specified pressure measured at the lowest end.
2. Fill piping section under test slowly with potable water while venting air.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
1. Pressure test piping after completion of visible leaks test.
2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
   a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
   b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional Joint Test:
1. Joint testing will be allowed only for low head pressure piping.
2. Perform air or water test in accordance with ASTM C1103-03.

END OF SECTION
SECTION 15958
MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   2. Section 02318 - Trenching.
   5. Section 16222 - Motors.

1.02 REFERENCES

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

B. American National Standards Institute/Hydraulic Institute (ANSI/HI):
   1. ANSI/HI 1.1-1.5 Standard for Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.
   2. ANSI/HI 1.6 Standard for Centrifugal Pump Tests.
   8. ANSI/HI 5.1-5.6 Standard for Sealless Centrifugal Pumps for Nomenclature, Definitions, Application, Operation and Test.
1.03 SUBMITTALS

A. Schedule of factory tests.
B. Test instrumentation calibration data.
C. Test result reports.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 QUALITY CONTROL TESTING AND REPORTING

A. Scheduling and Notification:
   1. Witnessed Source Quality Control Tests: Schedule test date and notify ENGINEER at least 30 days prior to start of test.
   2. Field Quality Control Tests: Schedule test date and notify ENGINEER at least 7 days prior to start of test.

B. Testing Levels:
   1. Test equipment based on test levels specified in the equipment Section of the Specifications.
   2. Requirements for Test Levels 1 to 2 are defined below.
   3. Test levels apply for both Source (Factory) Quality Control Tests and Field Quality Control Tests as specified in the individual equipment Sections of the Specifications.

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

D. Instrumentation: Provide necessary test instrumentation which has been calibrated within one year from date of test to recognized test standards traceable to the National Institute of Standards and Technology, Washington, D.C. or approved source. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for Field Quality Control Tests.

E. Temporary Facilities and Labor: Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing. With OWNER's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

F. Test Fluids:
   1. Factory Tests: Use water or air as appropriate at ambient conditions unless specified otherwise in the equipment Section.
   2. Field Tests: Use specified process fluid at available conditions.
G. Pressure Testing: Hydrostatically pressure test pressure containing parts in the factory at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher. Submit pressure test reports before shipping.

H. Test Measurement and Result Accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

I. Reports: Submit reports for Source Testing. Submit Source Quality Control Test result reports before shipping equipment to the field. Report features:
   1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
   2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
   3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
   4. Include appendix with the make, model and last calibration date of instrumentation used for test measurements.
   5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

3.02 EQUIPMENT TESTING, GENERAL

A. Tests for Pumps, All Levels of Testing:
   1. Test in accordance with applicable Hydraulic Institute Standards in addition to the requirements in this and other Sections.
   2. Test Tolerances: In accordance with appropriate Hydraulic Institute Standards, except the following modified tolerances apply:
      a. From 0 to plus 5 percent of head at the rated design point flow.
      b. 0 to plus 5 percent of flow at the rated design point head.
      c. No negative tolerance for the efficiency at the rated design point.
      d. No positive tolerance for vibration limits. Vibration limits and test methods in Hydraulic Institute Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

B. Tests for Drivers: Test motors as specified in Section 16222. Test other drivers as specified in the driver equipment Section.

3.03 REQUIREMENTS FOR VIBRATION TESTING

A. Definitions:
   1. Peak to Peak Displacement: The root mean squared average of the peak to peak displacement multiplied by the square root of 2.
2. Peak Velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.

3. Peak Acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.

4. High Frequency Enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectra of acceleration versus frequency. Manufacturers: One of the following or equal:
   b. CSI, "PeakVue."

5. Low Speed Equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.

6. High Speed Equipment: Equipment and equipment components operating at or above 600 revolutions per minute.

B. Vibration Instrumentation Requirements:
1. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, RS232C data output port, circuitry for integration of acceleration data to velocity or double integration to displacement. Manufacturers: One of the following or equal:
   a. Entek-IRD, Division of Rockwell Automation, Enpac 1200 with applicable data analysis software or Entek Model 838 analyzer with built in printer.
   b. Computational Systems Inc., (CSI) Division of Emerson Electric, Model 2120A, Data Collector/analyzer with applicable analysis software.

2. Analyzer Settings:
   a. Units: English, inches/second, mils and g's.
   b. Fast Fourier Transform Lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 rpm; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
   c. Sample Averages: 4 minimum.
   d. Maximum Frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
   e. Amplitude Range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
   g. High Pass Filter: Minus 3 db at 120 cycles per minute for high speed equipment. Minus 3 db at 21 cycles per minute for low speed equipment.

3. Accelerometers:
   a. For Low Speed Equipment: Low frequency, shear mode accelerometer, 500 millivolts per g sensitivity, 10 g range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount. Manufacturers: One of the following or equal:
      1) Wilcoxon Research, Model 797L.
      2) PCB, Model 393C.
   b. For High Speed Equipment: General purpose accelerometer, 100 millivolts per g sensitivity, 50 g range, plus/minus 3dB frequency
Conformity to 2 hertz to 12,000 hertz when stud mounted, with
magnetic mount holder. Manufacturers: One of the following or equal:
1) Wilcoxon Research, Model 793.
2) Entek-IRD Model 943.

C. Accelerometer Mounting:
   1. Use magnetic mounting or stud mounting.
   2. Mount on bearing housing in location with best available direct path to bearing
      and shaft vibration.
   3. Remove paint and mount transducer on flat metal surface or epoxy mount for
      High Frequency Enveloping measurements.

D. Vibration Testing Results Presentation:
   1. Provide equipment drawing with location and orientation of measurement
      points indicated.
   2. For each vibration measurement take and include appropriate data on
      equipment operating conditions at the time vibration data is taken; for pumps,
      compressors, and blowers record suction pressure, discharge pressure, and
      flow.
   3. When Vibration Spectra Data Required:
      a. Plot peak vibration velocity versus frequency in cycles per minute.
      b. Label plots showing actual shaft or part rotation frequency, bearing inner
         and outer race ball pass frequencies, gear mesh frequencies and relevant
         equipment excitation frequencies on the plot; label probable cause of
         vibration peaks whether in excess of specification limits or not.
      c. Label plots with equipment identification and operating conditions such as
         tag number, capacity, pressure, driver horsepower and point of vibration
         measurement.
      d. Plot motor spectra on a log amplitude scale versus frequency.
   4. For low speed equipment, plot peak vibration displacement versus frequency
      as well as velocity versus frequency.
   5. Provide name of manufacturer and model number of the vibration
      instrumentation used, including analyzer and accelerometer used together with
      mounting type.

3.04 TESTING LEVELS

A. Level 1 Quality Control Tests:
   1. Level 1 General Equipment Performance Test:
      a. For equipment, operate, rotate or otherwise functionally test for
         15 minutes minimum after components reach normal operating
         temperatures.
      b. Operate at rated design load conditions.
      c. Confirm that equipment is properly assembled, equipment moves or
         rotates in the proper direction, shafting, drive elements and bearings are
         installed and lubricated in accordance with proper tolerances, and that no
         unusual power consumption, lubrication temperatures, bearing
         temperatures, or other conditions are observed.
   2. Level 1 Pump Performance Test:
      a. Measure flow and head while operating at or near the rated condition; for
         factory testing, testing may be at reduced speeds with flow and head
corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.

b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 or the applicable equipment Section. Use actual driver for field tests.

c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.

3. Level 1 Vibration Test:
   a. Test Requirement: Measure filtered vibration spectra for peak velocity and peak to peak displacement versus frequency in three perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; one plane of measurement to be parallel to the axis of rotation of the component.
   b. Equipment Operating Condition: Test at specified maximum speed.

4. Level 1 Noise Test:
   a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Quality Control Tests:
   1. Level 2 General Performance Test:
      a. For equipment, operate, rotate or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
      b. Operate at rated design load conditions.
      c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

   2. Level 2 Pump Performance Test:
      a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
      b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
      c. Test for flow and head at two additional conditions; one at 25 percent below the rated flow and one at 10 percent above the rated flow.
      d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

   3. Level 2 Vibration Test:
      a. Test Requirement: Measure filtered vibration spectra for peak velocity, peak to peak displacement versus frequency and measure vibration phase in three perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; one plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
b. Equipment Operating Condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

c. Natural Frequency Test of Field Installed Equipment:
   1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears and supports.
   2) Perform test at each bearing housing and at each support pedestal and for pumps on the suction and discharge piping.
   3) Perform with equipment and attached piping full of intended service or process fluid.

4. Level 2 Noise Test:
   a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at three feet horizontally from the surface of the equipment at mid-point height of the noise source.

3.05 SOURCE QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in individual equipment sections. Prepare and submit test reports as specified.

B. Inspection and Balancing:
   1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
   2. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

C. Critical Speed of Rotating Equipment: Satisfy the following:
   1. First critical speed of the constant, variable, and 2-speed driven equipment is to be at least 25 percent above the maximum operating speed or 25 percent below the minimum operating speed.
   2. Second critical speed of any 2-speed or the variable speed equipment is to be at least 25 percent above or below the maximum operating speed or 25 percent below the minimum operating speed.

3.06 FIELD QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in individual equipment Sections. Prepare and submit test reports as specified. Comply with latest version of applicable standards.

B. For variable speed equipment, conduct test to establish performance over the entire speed range and at the average operating condition. Establish performance curves for:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.
3.07 VIBRATION ACCEPTANCE CRITERIA

A. Testing of Rotating Mechanical Equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.

B. Vibration Velocity Limits: Unless otherwise specified, equipment is not to exceed the following peak velocity limits:

<table>
<thead>
<tr>
<th>Item</th>
<th>Unfiltered Overall Limit (inches per second)</th>
<th>Any Filtered Peak Limit (inches per second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Clog or Mixed Flow Pumps</td>
<td>0.35</td>
<td>0.25</td>
</tr>
<tr>
<td>Clean Fluid Pumps</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Motors and Steady Bearings</td>
<td>0.25</td>
<td>0.20</td>
</tr>
</tbody>
</table>

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

C. Equipment Operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

D. Additional Criteria:
1. No narrow band spectral vibration amplitude components, whether subrotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer’s detailed verification of origin and ultimate effect of such excitation.
2. The presence of discernable vibration amplitude peaks in Test Level 2 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
3. For Motors, the Following Shall be Cause for Rejection:
   a. Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.
   b. Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
   c. Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around two times the rotor bar pass frequency.
   d. Phasing problems evidenced by one third line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4. The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.
E. Witnessing of Source Quality Tests shall be done in the presence of City’s staff or
the City’s representatives. CONTRACTOR shall give notice to the City of the time of
conducting vibration tests at least 10 calendar days prior to the proposed test date.
Should the vibration test results exceed the limits specified, CONTRACTOR shall
correct the deficiencies. After corrections have been made, the vibration testing
shall be rerun and the results resubmitted to ENGINEER for review. Corrections
shall continue until results meet the Specifications. Expenses for the re-witnessing
of the tests shall be paid by the CONTRACTOR.

3.08 NOISE REQUIREMENTS AND CONTROL

A. Make measurements in relation to reference pressure of 0.0002 microbar.

B. Make measurements of emitted noise levels on sound level meter meeting or
exceeding ANSI S1.4, Type II.

C. Set sound level meter to slow response.

D. Unless otherwise specified, the maximum noise level during normal operation of all
equipment with room accoustical panels installed shall not exceed 85 dBA when
measured anywhere in the room and no closer than 3 feet from any operating
equipment.

E. Witnessing of Source Quality Tests shall be done in the presence of City’s staff or
the City’s representatives. CONTRACTOR shall give notice to the City of the time of
conducting noise tests at least 10 calendar days prior to the proposed test date.
Should the noise test results exceed the limits specified, CONTRACTOR shall
correct the deficiencies. After corrections have been made, the noise testing shall
be rerun and the results resubmitted to ENGINEER for review. Corrections shall
continue until results meet the Specifications. Expenses for the re-witnessing of the
tests shall be paid by the CONTRACTOR.

END OF SECTION
SECTION 16050
GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all electrical work.
   2. General requirements for electrical submittals.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all
      Divisions and Sections apply. It is the responsibility of the CONTRACTOR and
      its subcontractors to review all sections to ensure a complete and coordinated
      project:
      a. Items involving electrical, control, and instrumentation construction may
         be indicated on the Drawings or referred to in specifications that do not
         apply specifically to electrical, control and instrumentation systems.

C. Interfaces to Equipment, Instruments, and Other Components:
   1. The drawings, specifications, and overall design are based on preliminary
      information furnished by various equipment manufacturers, which identify a
      minimum scope of supply from the manufacturers. This information pertains to,
      but is not limited to, instruments, control devices, electrical equipment,
      packaged mechanical systems, and control equipment provided with
      mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished,
      and include all costs to add any additional conduit, wiring, terminals, or other
      electrical hardware to the work, which may be necessary to make a complete,
      functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer’s wiring
         requirements.
   3. Submit all such changes and additions to the ENGINEER for acceptance in
      accordance with the General Conditions.
   4. Review the complete set of drawings and specifications in order to ensure that
      all items related to the electrical power and control systems are completely
      accounted for. Include any such items that appear on drawings or in
      specifications from another discipline in the scope of Work:
      a. If a conflict between drawings and specifications is discovered, refer
         conflict to the ENGINEER as soon as possible for resolution.
   5. Loop Drawings:
      a. Provide complete loop drawings for all systems, including packaged
         equipment furnished as part of a vendor furnished package, and for all
         pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must
         match that of the sample loop drawing included in the Contract
         documents.
6. The OWNER and ENGINEER are not responsible for providing detailed loop diagrams for CONTRACTOR furnished equipment.

D. All electrical equipment and systems for the entire project must comply with the requirements of Division 16, whether referenced in the individual equipment specifications or not:
   1. The requirements of Division 16 apply to all electrical work specified in other Divisions and Sections, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying electrical equipment or systems of the requirements of Division 16.
   3. The OWNER is not responsible for any additional costs due to the failure of the CONTRACTOR to notify all subcontractors and suppliers of the Division 16 requirements.

E. Special Subcontractor Requirements:
   1. As specified elsewhere in Section 16050, provide the work specified in Divisions 16 and 17, as well as the work shown on the electrical and the instrumentation drawings.

F. Contract Documents:
   1. General:
      a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The electrical drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the electrical work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation. Use the entire drawing set for construction purposes.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions shown on plans and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) The CONTRACTOR has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the ENGINEER has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer’s equipment fits in the allotted space. It is the CONTRACTOR’s responsibility to ensure that the equipment being furnished fits within the defined space.
c. Installation Details:
   1) The contract drawings include typical installation details, which show
      the means and methods the CONTRACTOR is to use to install
      electrical equipment. For cases where a typical detail does not apply,
      develop installation details that may be necessary for completing the
      Work, and submit these details for review by the ENGINEER.

d. Schematic Diagrams:
   1) All controls are shown de-energized.
   2) Schematic diagrams show control function only. Incorporate other
      necessary functions for proper operation and protection of the
      system.
   3) Add slave relays, where required, to provide all necessary contacts
      for the control system or where needed to function as interposing
      relays for control voltage coordination, equipment coordination, or
      control system voltage drop considerations.
   4) Mount all devices shown on motor controller schematic diagrams in
      the controller compartment enclosure, unless otherwise noted or
      indicated.
   5) Control schematics are to be used as a guide in conjunction with the
      descriptive operating sequences found in the drawings or
      specifications. Combine all information and furnish a coordinated and
      fully functional control system.

G. Alternates/Alternatives:
   1. Refer to the General Conditions for substitute item provisions.

H. Changes and Change Orders:
   1. Refer to the General Conditions.

1.02 REFERENCES

A. Code Compliance:
   1. As specified in Section 01410.
   2. The publications are referred to in the text by the basic designation only. The
      latest edition accepted by the Authority Having Jurisdiction of referenced
      publications in effect at the time of the bid governs.
   3. The Standards Listed are Hereby Incorporated into these Specifications:
      b. Institute of Electrical and Electronic Engineers (IEEE).
      c. National Electrical Manufacturers Association (NEMA).
      e. Underwriters' Laboratories, Inc. (UL).
      f. Insulated Power Cable Engineers Association (IPCEA).
      g. American National Standards Institute (ANSI).
      i. National Bureau of Standards.
      j. Institute of Power Cable Engineers Association National Board of Fire
         Underwriters (NBFU).
      k. Illuminating Engineering Society (IES) of North America.
      l. Safety Orders of Industrial Accident Commission.
      m. Rules of the National Board of Fire Underwriters.
      n. Requirements of the serving Utilities.
B. Compliance with Laws and Regulations:
   1. Refer to the General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth in the:
   2. Institute of Electrical and Electronic Engineers.

B. Specific Definitions:
   1. FAT: Factory Acceptance Test.
   2. ICSC – Instrumentation and Controls Subcontractor.
   3. PCIS – Process Control and Instrumentation System.
   4. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e. provide all standoffs, bus, and hardware, as part of the space.
   5. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
   6. Unequipped Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General Requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the electrical work described in the drawings and specifications and reasonably inferable there from:
      a. The electrical drawings are schematic in nature use the structural, architectural, mechanical, and civil drawings for all dimensions and scaling purposes.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all: connections, testing, calibration of equipment furnished by others as well as equipment furnished by the CONTRACTOR, whether or not specifically mentioned, but which are necessary for successful operation.
   3. Provide all electrical work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of Division 16 for all aspects of the Work, including heating, ventilation, and air conditioning.
   4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The OWNER is not responsible for any change orders due to lack of coordination of the Work between the
CONTRACTOR, the electrical subcontractor, the other subcontractors or suppliers.

5. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the electrical work and installation.
   a. Refer to Divisions 2 and 3.

6. Defective work:
   a. Refer to the General Conditions.

7. Utility Coordination: Coordinate with the electric and telephone utilities as required by Section 16210, Utility Coordination.

1.05 SUBMITTALS

A. General:
   1. Furnish Submittals that are fully indexed with a tabbed divider for every component.
   2. Sequentially number pages within the tabbed sections. Submittals and Operation and Maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
   3. Edit all Submittals and Operation and Maintenance Manuals so that the submittal specifically applies to only the equipment furnished. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
   4. Instruct all equipment suppliers of Submittal and Operation and Maintenance Manuals of the requirements in Section 16050.
   5. Submittal Requirements:
      a. Submit copies of shop drawings, and product data, in accordance with Section 01330 in addition to the requirements of this Section:
         1) Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
      b. Where Submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the CONTRACTOR may make more than one submittal per specification section, but a single submittal may not cover more than one specification section:
         1) The only exception to this requirement is when one specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
   6. Exceptions to Specifications and Drawings:
      a. Include a list of proposed exceptions to the specifications and drawings along with a detailed explanation of each.
      b. Any exceptions to the specification and drawings must be noted and the reason for the exception explained.
      c. If there is insufficient explanation for the deviation, the submittal will be returned requiring Revision and Re-submittal.
      d. Acceptance of any exception is at the sole discretion of the ENGINEER. Furnish all items (materials, features, functions, performance, etc.) that
are not listed as exceptions strictly in accordance with the specifications and drawings.

e. Replace all items that do not strictly meet the requirements of the specifications, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

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

8. Specific Submittal Requirements:
   a. Furnish the submittals required by each Section in Division 16 in accordance with the following requirements.
b. Shop Drawings:
   1) Required for materials and equipment listed in this and other sections.
   2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
   3) Shop Drawings Requirements:
      a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
      b) Locations of conduit entrances and access plates.
      c) Component layout and identification.
      d) Schematic and wiring diagrams with wire numbers and terminal identification.
      e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      f) Anchoring method and leveling criteria, including manufacturer’s recommendations for the seismic conditions specified in Section 01612.
      g) Weight.
      h) Finish.
      i) Nameplates.
         (1) Refer to Section 16075.
      j) Temperature limitations, as applicable.

c. Product Data:
   1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
   2) Include:
      a) Catalog cuts.
      b) Bulletins.
      c) Brochures.
      d) Quality photocopies of applicable pages from these documents.
      e) Identify on the data sheets the project name, applicable specification section, and paragraph.
      f) Identify model number and options for the actual equipment being furnished.
      g) Neatly cross out options that do not apply or equipment not intended to be supplied.
      h) Manufacturer’s original full size transparent time-current characteristic curves for all fuses, circuit breakers, and protective relays in 11-inch by 17-inch format.

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

e. Completely fill out a Motor Data Sheet, refer to Section 16222, for every motor furnished:
   1) Submit one copy of the Motor Data Sheet to the ENGINEER for review as part of the associated equipment submittal.

f. Adhere to the wiring numbering scheme outlined in Section 16075 throughout the Project:
   1) Uniquely number each wire.
   2) Wire numbers must appear on all equipment drawings.

g. Only use equipment and instrument tags, as depicted on the drawings, for all submittals.
B. Operation and Maintenance Manuals:
   1. Furnish the ENGINEER with a complete set of written Operation and
      Maintenance Manuals eight weeks before energization start-up and/or
      commissioning.
   2. Furnish in accordance Section 01782, and the following additional
      requirements:
      a. Completely Index Manuals with a Tab for Each Section:
         1) Each section containing applicable data for each piece of equipment,
            system, or topic covered.
         2) Assemble manuals using the approved shop drawings, and include,
            the following types of data:
            a) Complete set of 11-inch by 17-inch drawings of equipment.
            b) Complete set of 11-inch by 17-inch drawings of the control
               system.
            c) Complete set of control schematics.
            d) Complete parts list for all equipment being provided.
            e) Catalog data for all products or equipment furnished.

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

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

E. Installation Recommendations:
   1. Submit the manufacturer’s printed recommendations for installation of
      electrical equipment.

F. Record Documents:
   1. Furnish in accordance with Section 01770.
   2. Provide Record Documents of all electrical drawings.
   3. Record Drawing Requirements:
      a. Update Record Drawings weekly.
      b. Record Drawings must be fully updated as a condition of the monthly
         progress payments.
      c. Submit Record Drawings upon completion of the Work for final review.
      d. Clearly and neatly show all changes in accordance with Section 01770.
   4. Shop Drawings:
      a. Upon completion of the Work, update all shop drawings to indicate the
         final as-built configuration of the systems:
         1) Provide as-built Shop drawings for all electrical equipment on 11-inch
            by 17-inch using Bond paper.
         2) Provide electronic copies of these documents on CD-ROM disks in
            AutoCad Version 2000 by Autodesk. Size all drawings to be readable
            and legible on 11-inch by 17-inch media.
      b. Furnish written information prepared specifically for this project using
         Microsoft Word 2000 and printed on 8.5-inch by 11-inch plain bond paper:
1) Provide electronic copies of these documents on CD-ROM disks.

5. Review and Corrections:
   a. Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit Record Documents returned for correction.

G. Test Reports:
   1. Include the Following:
      a. A description of the test.
      b. List of equipment used.
      c. Name of the person conducting the test.
      d. Date and time the test was conducted.
      e. All raw data collected.
      f. Calculated results.
   2. Each report signed by the person responsible for the test.
   3. Additional requirements for acceptance test reports are listed in Section 16950.

H. Calculations:
   1. Where required by specific Division 16 Specifications:
      a. Because these calculations are being provided by a Registered Professional Engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

I. Factory Acceptance Test:
   1. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Perform all electrical Work, whether needed for the power, control system, process, HVAC, telephone, security, etc. in accordance with all codes and standards required by Division 16.

B. Furnish all equipment listed by and bearing the label of Underwriters’ Laboratories, Incorporated (UL) or of an independent testing laboratory acceptable to the ENGINEER and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Shipping Precautions:
   1. After completion of shop assembly and successful factory acceptance test, pack all equipment in protective crates, and enclose in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   2. Place dehumidifiers, when required, inside the polyethylene coverings.
   3. Skid-mount the equipment for final transport.
   4. Provide lifting rings for moving without removing protective covering.
   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
B. Delivery and Inspection:
1. Deliver products in undamaged condition, in manufacturer’s original container or packaging with identifying labels intact and legible. Include date of manufacture on label.
2. Unload products in accordance with manufacturer’s instructions for unloading, or as specified. Record the receipt of products at the site. Inspect for completeness and evidence of damage during shipment.
3. Remove damaged products from the site, expedite delivery of identical new undamaged products, augment incomplete shipments or replace lost products in order not to delay the progress of the Work.

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

D. Storage and Protection:
1. Provide for the safe storage and delivery of materials, whether furnished by the CONTRACTOR or by others.
2. Meet all storage requirements of the manufacturer and provide for the safe storage of all materials and equipment as recommended by the manufacturer.
3. Protect electrical work at all times from damage, defacement or deterioration from any cause whatever:
   a. Provide proper storage facilities and conduct operations to this effect.

1.08 PROJECT OR SITE CONDITIONS

A. Site Conditions:
1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the site as specified in the General Requirements and below.
2. Seismic Classification:
   a. Provide all electrical equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612.
3. Wind:
   a. Provide all electrical equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614.
4. Altitude, Temperature and Humidity:
   a. Refer to Section 15050.
   b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional de-rating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer’s guidelines:
      1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether shown on the drawings or not.
5. Site Security:
   a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329.
6. Outdoor Installations:
a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
b. Provide heating, cooling, and de-humidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
   1) Provide all wiring necessary to power these devices.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
   1. NEMA 1 Enclosures: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
   2. NEMA 4 Enclosures: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
   3. NEMA 4X Enclosures: Made from corrosion resistant materials (Fiberglass reinforced plastic, 316 Stainless Steel or equal) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
   4. NEMA 12 Enclosures: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

C. Plant Area Electrical Work Requirements:
   1. Provide all electrical Work in accordance with the designation on the Drawings or in the Conduit Schedule:

1.09 SCHEDULING

A. General:
   1. Refer to Section 01312.
   2. Testing requirements are specified in Section 16950 and other Sections.
   3. General scheduling requirements are specified in Section 01324.
   4. Work restrictions and other scheduling requirements are specified in Section 01140.

B. Pre-Submittal Conference:
   1. Before producing any submittals, schedule a pre submittal Conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
   2. The CONTRACTOR, instrumentation and control subcontractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend, including but not limited to:
      a. Motor Control Centers.
      b. Switchgear.
      c. Variable Frequency Drives.
      d. Lighting.
C. Factory Acceptance Testing:
   1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the ENGINEER in writing when the equipment is completed and ready for factory inspection and testing:
      a. Indicate the desired dates for inspection and testing.
      b. Schedule the FAT after Approval of the FAT Procedures Submittal:
         1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date
         2) Notify the ENGINEER of the scheduled tests a minimum of 10 days before the date of the test.

1.10 WARRANTY

A. Warrant the Electrical Work in Accordance with the General Conditions:
   1. Provide additional warranty as specified in the individual Division 16 Specifications.

1.11 SYSTEM STARTUP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the ENGINEER

1.12 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

B. Allowable manufacturers are specified in individual electrical and equipment specifications in other sections of Division 16.

2.02 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the specifications.
B. Provide materials complying with the applicable industrial standard in accordance with the General Conditions.

C. Stainless Steel:
   1. Where stainless steel is indicated or used for any portion of the electrical work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Provide finished material free of any burrs or sharp edges.
   4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
   5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA 4X construction.

2.03 SOURCE QUALITY CONTROL

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

B. Arrange with all manufacturers of the electrical equipment, to allow the OWNER and ENGINEER to inspect and witness the testing of the equipment at the site of fabrication:
   1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.

C. Factory testing is specified in the individual sections of Divisions 16.

PART 3 EXECUTION

3.01 EXAMINATION

A. Review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

B. Provide a Complete Electrical System:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, PCIS, and HVAC system.

3.02 INSTALLATION

A. The construction and installation of all electrical equipment and materials must comply with all applicable provisions of:
   1. Section 01410.
   2. Division 16.
   4. Applicable local codes and regulations.

B. Equipment locations shown on electrical drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
a. Actual field conditions govern all final installed locations, distances, and levels.

2. Review all information shown on the drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.

3. Make minor changes in location of equipment before rough in, as directed by the OWNER or ENGINEER.

C. Install all material and equipment in accordance with the manufacturer’s installation instructions:
   1. Where CONTRACTOR asks to deviate from the manufacturer’s recommendations, such changes must be reviewed and accepted by the ENGINEER and manufacturer before installation.

D. Cutting and Patching:
   1. Perform all cutting, patching, channeling, core drilling, and fitting required for the electrical Work, except as otherwise directed:
      a. Secure the permission of the ENGINEER before performing any operation likely to affect the strength of a structural member:
         1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      b. Review the complete drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
   2. Perform all patching to the same quality and appearance as the original Work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
      a. 3M CP25 Caulk.
      b. 3M 303 Putty.
      c. T&B S-100 Caulk.
      d. T&B FS-500 Putty.
      e. T&B FST-601 Putty.
   3. Seal around conduit penetrations of below grade walls with a waterproof, non shrink, non-metallic grout, unless otherwise indicated on the typical installation details:
      a. Use the installation details provided in the drawings as a guide for acceptable sealing methods.

E. Install all conduit and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
   1. Install all conduits and equipment in accordance with working space requirements as outlined in Article 110] Requirements for Electrical Installations of the National Electrical Code.
   2. Where the drawings do not show dimensions for locating equipment, install equipment in approximate locations as indicated on the Drawings. Adjust
locations shown on the drawings as necessary to avoid any obstruction or interferences.
3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
4. Where the drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details shown in the drawings.

F. Earthwork and Concrete:
1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the electrical Work:
   a. In accordance with Division 2 and 3 requirements.

G. Roof Penetrations:
1. Make all roof penetrations, and seal around all conduits. Use pitch pockets and flashings.
2. Roofing subcontractor to make actual seals around roof penetrations.

H. Terminations:
1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

I. Miscellaneous Installation Requirements:
1. In case of interference between electrical equipment shown on the drawings and the other equipment, refer to the General Conditions for direction.
2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with mechanical and civil Work.
3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
4. Circuits of Different Service Voltage:
   a. Voltage and Service Levels:
      1) Medium Voltage: greater than 1.0kV.
      2) Low Voltage: 120V to 480V.
      3) Instrumentation: less than 50VDC.
   b. Install in separate raceways, junction boxes, manholes, hand holes, and pullboxes.
   c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.
5. Install all conduits located below slab on grade in reinforced concrete duct banks.

J. Labeling:
1. Provide all nameplates and labels as required in specification Sections 16075 and 16305.

K. Equipment Tie-Downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with Section 16070.
3.03 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of electrical system installation in accordance with Section 01450.
2. Provide any assistance necessary to support inspection activities.
3. ENGINEER Inspections May Include, but are Not Limited to, the Following:
   a. Inspect equipment and materials for physical damage.
   b. Inspect installation for compliance with drawings and Specifications.
   c. Inspect installation for obstructions and adequate clearances around equipment.
   d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
   e. Inspect equipment nameplate data to verify compliance with design requirements.
   f. Inspect raceway installation for quality workmanship and adequate support.
   g. Inspect cable terminations.
   h. Schedule Structural Engineer to inspect all mounting of electrical devices and all penetration and connections to structures.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements outlined in Section 16950.

B. Field Testing:
1. Notify the ENGINEER when the electrical Work is ready for field acceptance testing.
2. Perform the acceptance tests in accordance with Section 16950.
3. Record Results of the Required Tests Along with the Date of Test:
   a. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:
1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
   a. Neatly coil and label spare wiring lengths.
   b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the ENGINEER.

3.04 CLEANING

A. Refer to Section 01770.

B. General Requirements:
1. Remove all foreign material and restore all damaged finishes to the satisfaction of the ENGINEER and OWNER.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start up:
   1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the OWNER.
E. As specified in other Sections of the Contract Documents.

3.05 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual specification sections.

3.06 PROTECTION

A. Protect all work from damage or degradation until substantial completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Grounding electrodes.
   2. Grounding electrode conductors.
   3. Equipment grounding conductors.
   4. Main bonding jumper.
   5. Ground connections.
   6. General requirements for grounding.

B. Related Sections:
   1. Contract Documents are a single integrated document, and as such all divisions and Sections apply. It is the responsibility of the CONTRACTOR and its subcontractors to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 16050.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide an electrical grounding system as indicated on the Drawings and as specified.

C. Provide Complete Grounding System Including but Not Limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.

D. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

E. The ground system resistance (electrode to ground) of the completed installation, as determined by tests required by Section 16950, shall be:
   1. Five ohms or less for industrial systems.
1.05 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330 and 16050.

B. Product Data:
   1. Catalog Cut Sheets.

C. Testing Resume:
   1. Submit a written resume for the individual who will perform the grounding tests detailing experience and qualifications.
   2. Submit detailed information concerning test instrument, and tester's qualifications to perform the specified tests.

1.06 QUALITY ASSURANCE
A. Refer to Section 16050.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 16050.

1.08 WARRANTY
A. Refer to Section 16050.

1.09 SYSTEM START UP
A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Compression Connectors: One of the following or equal:
   1. FCI Burndy.
   2. Thomas and Betts.

B. Exothermic Connectors: One of the following or equal:
   1. Erico.
   2. Harger.

C. Ground Rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Conex.

D. Ground Cable: One of the following or equal:
   1. Nehring.
   2. Harger.

2.02 MATERIALS

A. Ground Rod:
   1. Minimum: 3/4 inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. Conforming to UL 467.
   4. Sectional type joined by compression copper alloy couplings.
   5. Fit the top of the rod with a coupling and steel-driving stud.

B. Ground Cable:
   1. Requirements:
      a. Annealed.
      b. Concentric lay stranded.
      c. Bare copper.
      d. Coarse stranding.
      e. Ninety-eight percent conductivity.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression Connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.

D. Exothermic Welds:
   1. Current carrying capacity equal to that of the conductor.
   2. Permanent molecular bond that cannot loosen or corrode over time.
   3. Will not deteriorate with age.

E. Equipment Grounding Conductors:
   1. Conductors shall be the same type and insulation as the load circuit conductors:
      a. Use 600-volt insulation for the equipment grounding conductors.
   2. The minimum size shall be as required by the National Electrical Code.
   3. Provide in all raceways. The conduit system is not an allowable equipment ground.

F. Grounding Electrode Conductors:
   1. The minimum size shall be as required by National Electrical Code.

G. Main Bonding Jumpers and Bonding Jumpers:
   1. The minimum size shall be as required by National Electrical Code.
PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
   1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
   2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by Variable Frequency Drives (VFD) comply with the requirements of the VFD Manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each MCC section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct Bank Ground System:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as detailed on the Drawings and Specifications.
   2. Make all splices.
   3. Install all ground rods.
   4. Make connections to all equipment and structures.

I. Grounding at Service (600V or Less): Provide grounding at service as follows:
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. Ground Connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
3. Do not conceal or cover any ground connections until the ENGINEER or authorized representative has established and provided written confirmation that every grounding connection conforms to the Drawings and Specifications.

K. Grounding Electrode System:
1. Ground Ring:
   a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
   b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size shown on the drawing.
   c. Minimum burial depth 36 inches or as indicated on the Drawings.
   d. Re-compact disturbed soils to original density in 6-inch lifts.
2. Ground Rods:
   a. Locations as indicated on the Drawings.
   b. Length of rods forming an individual ground array shall be equal in length.
   c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
3. Metal Underground Water Pipe:
   a. Bond metal underground domestic water pipe to grounding electrode system.
4. Metal Frame of Building or Structure:
   a. Bond metal frame of building or structure to grounding electrode system.
5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. Shield Grounding:
1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
   a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
2. Terminate the shield drain wire on a dedicated terminal block.
3. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Antenna Ground:
1. Install individual ground rod or ground system for communication system antenna:
   a. Install a dedicated grounding electrode conductor from the antenna ground to the grounding electrode system.
   b. Do not connect any other grounds to the antenna grounding electrode conductor.
2. Install ground rod or ground system in accordance with the radio manufacturer's requirements.

N. Where indicated on the Drawings install ground rods in a precast ground wells as specified in Section 02084.
3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. Measure ground impedance in accordance with IEEE 81 after installation before connecting the electrode to the remaining grounding system.

3.03 ADJUSTING

A. Under the direction of the ENGINEER, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.04 PROTECTION

A. Refer to Section 16050.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Identifying electrical, instrumentation, and process equipment and components.

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

1.02 REFERENCES

A. Refer to Section 16050.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Nameplates:
   1. Provide a nameplate for each piece of mechanical equipment, process equipment, valve, pump, mixer, feeder, fan, air-handling unit, motor, switch, receptacle, controller, instrument transducer, instrument power supply, solenoid, motor control center, starter, panelboard, switchboard, individually mounted or plug-in type circuit protector or motor controller, disconnect switch, bus duct tap switch, time switch, relay and for any other control device or major item of electrical equipment, either located in the field or within panels.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device Nameplates Information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
      b. Device tag and loop number ID (e.g. EDV-60.0101.01).
      c. Circuit ID (e.g. LPA-11).
      d. Area served (e.g. Lighting Chemical Building).

B. Wire Numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
c. Internal panel wires on a common terminal shall have the same wire number.
d. Multiconductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
   1) Label armored multiconductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130.
2. Provide the following wiring numbering schemes throughout the project for field wires between Process Control Module, (PCM), Vendor Control Panels, (VCP), Motor Control Centers, (MCC), field starters, field instruments, etc.

\[
\text{(ORIGIN LOC.)} \Rightarrow \text{(ORIGIN TERM.)} \Rightarrow (\text{DEST. LOC.}) \Rightarrow (\text{DEST. TERM.})
\]

OR

\[
(\text{ORIGIN LOC.)} \Rightarrow (\text{ORIGIN TERM.})
(\text{DEST. LOC.)} \Rightarrow (\text{DEST. TERM.})
\]

Where:

- ORIGIN LOC. = Designation for originating panel or device
- ORIGIN TERM. = Terminal designation at originating panel or device
- DEST. LOC. = Designation for destination panel or device
- DEST. TERM. = Terminal designation at destination panel or device or PLC I/O address at destination panel

a. Identify equipment and field instruments as the origin.
b. PCM’s are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCC’s, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments, and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multiconductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer’s standard terminal designation (e.g. T1, T2, T3, etc.).
f. Terminal designations at PCM’s where the field conductor connects to a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
   1) Discrete Point: \( W:X:Y/Z \)
Analog Point: $W:X:Y.Z$

Where:
- $W = I$ for input, $O$ for output
- $X = PLC$ number (1, 2, 3…)
- $Y = Slot$ number (01, 02, 03…)
- $Z = Terminal$ number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

**g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a “C” prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with “A” (e.g. C0010A).**

3. **Case 1:** Vendor Control Panel (VCP) to Process Control Module (PCM):
   Field Wire Number/Label: A-B/C-D
   - $A = $ Vendor Control Panel number without hyphen (VCP60.0101.01)
   - $B = $ Terminal number within VCP (manufacturer’s or vendor’s standard terminal number)
   - $C = $ Process Control Module number without hyphen (PCM60.0101)
   - $D = $ Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)

   **Examples:**
   - VCP60.0101.01-10/PCM60.0101-I:1:01/01
   - VCP60.0101.01-10/PCM60.0101-O:1:10/07
   - VCP60.0101.01-10/PCM60.0101-C0100

4. **Case 2:** Field Instrument to Process Control Module (PCM):
   Field Wire Number/Label: E-F/C-D
   - $C = $ Process Control Module number without hyphen (PCM60.0101)
   - $D = $ Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)
   - $E = $ Field mounted instrument tag and loop numbers without hyphen (EDV60.0101.01)
   - $F = $ Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   **Examples:**
   - TIT60.0101.01-2,3/PCM60.0101-I:1:01.1
   - TSH60.0101-1/PCM60.0101-I:2:01/00

5. **Case 3:** Motor Control Center (MCC) to Process Control Module (PCM):
   Field Wire Number/Label: G-B/C-D
   - $B = $ Terminal number within Motor Control Center (manufacturer’s or vendor’s standard terminal number)
   - $C = $ Process Control Module number without hyphen (PCM60.0101)
   - $D = $ Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)
   - $G = $ Actual starter designation in the Motor Control Center without hyphen (MMS60.0101)
6. **Case 4**: Motor Control Center (MCC) to Vendor Control Panel (VCP):
   Field Wire Number/Label: G-B/A-B
   A = Vendor Control Panel number without hyphen (VCP60.0101.01)
   B = Terminal number within motor control center or vendor control panel
       (manufacturer’s or vendors standard terminal number)
   G = Actual starter designation in the Motor Control Center without hyphen
       (MMS60.0101)

   Example: MMS60.0101-X2/VCP60.0101.01-10

7. **Case 5**: Motor leads to a Motor Control Center (MCC):
   Field Wire Number/Label: H-I/G-B
   B = Terminal number within motor control center (manufacturer’s standard
terminal number)
   G = Actual starter designation in the Motor Control Center without hyphen
       (MMS60.0101)
   H = Equipment tag and loop number without hyphen (PMP60.0101.01)
   I = Motor manufacturer’s standard motor lead identification (e.g. T1, T2, T3,
etc.)

   Example: PMP-60.0101.01-T3/MMS60.0101.01-T3

8. **Case 6**: Remote or separately mounted starter or Variable Frequency Drive
   (VFD) to Process Control Module (PCM):
   Field Wire Number/Label: J-B/C-D
   B = Terminal number within starter or Variable Frequency Drive
      (manufacturer’s standard terminal number)
   C = Process Control Module number without hyphen (VCP60.0101.01)
   D = Either the PLC address if the field terminal is connected directly to a PLC
      input or output point or the terminal number with a “C” prefix if not
      connected directly to a PLC I/O point (C0010)
   J = Starter or Variable Frequency Drive tag and loop number without hyphen
      (MMS60.0101)

   Examples: MMS60.0101-10/PCM60.0101.01-I:1:01/01
              MMS60.0101-10/PCM60.0101.01-O:2:10/07
              MMS60.0101-10/PCM60.0101.01-C0010

9. **Case 7**: Field Bus Trunk Segment:
   Field Cable Number/Label: C/K-L/M; C/K-L/H; C/K-L/J
   C = Process Control Module without hyphen (PCM60.0101).
   K = Field Bus Cable Type.
   L = Field Bus Segment Number
   M = Field Bus Field Network Component without hyphen (PTB1) or
   H = Equipment tag and loop number without hyphen (EMV61.1100.01) or
   J = Starter or Variable Frequency Drive tag and loop number without hyphen
      (VFD60.0112)
10. **Case 8:** Field Bus Spur (Drop):
    Field Cable Number/Label: E/K-L/M
    E = Field mounted instrument tag and loop numbers without hyphen (FIT62.0110.02)
    K = Field Bus Cable Type.
    L = Field Bus Segment Number
    M = Field Bus Field Network Component without hyphen (PTB1), identify ports on the device.

    Examples: FIT62.0110.02/PA-1C/PTB1-1
               FIT63.0110.01/PA-1D/PTB1-2

11. Terminate all spare conductors on terminal blocks and identify as required for other field wires with an “S” prefix:

    Example: S MMS60.0101-10/PCM60.0101.01-C011

1.05 **SUBMITTALS**

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

B. Product Data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate Schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire Numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record Documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 **QUALITY ASSURANCE**

A. Schedule a pre-installation conference in accordance with Sections 01312 and 16050 in order to clearly define the requirements specified for equipment identification:
1. Representatives of the CONTRACTOR, OWNER, and ENGINEER shall convene before any major purchases of cable or conductors and before the installation or termination of any cables or conductors.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 WARRANTY

A. Refer to Section 16050.

1.09 SYSTEM START UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and Signs:
   1. One of the Following or Equal:
      a. Brady.
      b. Seton.

B. Conductor and Cable Markers:
   1. Heat-Shrinkable Tubing:
      a. One of the Following or Equal:
         1) Raychem.
         2) Brady.
         3) Thomas & Betts.
         4) Kroy.
   2. Marker Printer:
      a. One of the Following or Equal:
         1) Brady XC Plus.
   3. Pre-Printed Slip-On Sleeve Markers:
      a. One of the Following or Equal:
         1) Grafoplast.
         2) ENGINEER knows of no equal.

C. Conduit and Raceway Markers:
   1. One of the Following or Equal:
      a. Almtek: Almetek Type Mini-Tag.
      b. ENGINEER knows of no equal.

D. Medium Voltage Raceway Voltage Labels:
   1. One of the Following or Equal:
      a. Brady.
      b. Seton.
2.02 MATERIALS

A. Nameplates:
   1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. Two-ply.
      c. With chamfered edges.
      d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
         1) No characters smaller than 1/8-inch in height.

B. Signs:
   1. Automatic Equipment and High Voltage Signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and Cable Markers:
   1. Machine printed black characters on white tubing.
   2. Ten point type or larger.

D. Conduit and Raceway Markers:
   1. UV resistant holder and letters.
   2. Black letters on yellow background.
   3. Minimum 1/2-inch high letters.

E. Medium Voltage Circuit Raceway Labels:
   1. Vinyl plastic.
   2. Minimum 1-inch high letters.

2.03 SOURCE QUALITY CONTROL

A. Nameplates:
   1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
      a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA 4, NEMA 4X, enclosures, use epoxy-based cement to attach nameplates.
3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
   a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the ENGINEER.

C. Conductor and Cable Markers:
   1. Apply all conductor and cable markers before termination.
   2. Heat-Shrinkable Tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit Markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule; refer to Drawings.
   2. Mark Conduits at the Following Locations:
      a. Each end of conduits that are greater that 10 feet in length.
      b. Where the conduit penetrates a wall or structure.
      c. Where the conduit emerges from the ground, slab, etc.
      d. The middle of conduits that are 10 feet or less in length.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Secure All Conduit Markers with Nylon Cable Ties:
      a. Provide with ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
   6. Conduit shall be identified with 0.036 minimum thickness solid brass tags with stamped 3/16-inch minimum height characters. Tags shall be attached to the raceway with Type 316 stainless steel wires.
   7. Mark conduits before construction review by ENGINEER for punch list purposes.
   8. Label intrinsically safe conduits in accordance with the requirements of the National Electrical Code (NEC).

E. Medium Voltage Raceway labels:
   1. Apply at 50 foot intervals stating the voltage level contained within the raceway.

F. Labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to Operations Personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, and where the voltage exceeds 600 volts.
3. Place warning signs on utilization equipment that has more than one source of power. Use warning signs to identify every panel and circuit number of the disconnecting means all external power sources:
   a. Place warning signs on utilization equipment that has 120 VAC control voltage source used for interlocking.
   b. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

G. Signs:
   1. Automatic Equipment and High Voltage Signs:
      a. Mount permanent warning signs at mechanical equipment that may be started automatically from remote locations. Fasten warning signs with round head stainless steel screws or bolts. Locate and mount warning signs in a suitable manner that is acceptable to the ENGINEER.
      b. Mount permanent and conspicuous warning signs on the front and back of equipment, doorways to equipment rooms, pull boxes, and manholes where the voltage exceeds 600 volts.
      c. Place warning signs on equipment that has more than one source of power:
         1) Warning sign to identify every power source.

3.02 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the ENGINEER do not meet the ENGINEER’s aesthetic requirements.

END OF SECTION
SECTION 16123
600 VOLT OR LESS WIRES AND CABLES

PART 1  GENERAL

1.01  SUMMARY

A.  Section includes requirements for:
1.  Six hundred Volt Class wire and cable.
2.  Instrumentation Class wire and cable.
3.  Network cable.
4.  Fire Alarm wire and cable.
5.  Telephone wire and cable.
6.  Six hundred Volt Class Tray cable.
7.  Six hundred Volt Class Armored cable.

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

1.02  REFERENCES

A.  Refer to Section 16050.

B.  American Society for Testing and Materials (ASTM):

C.  Federal Specification J-C 30A.

D.  Insulated Cable Engineers Association (ICEA):
1.  IPCEA S-61-402 for thermoplastic insulated wire and cable for the transmission and distribution of electrical energy.
2.  IPCEA S-61-402 for rubber insulated wire and cable for the transmission and distribution of electrical energy.

E.  National Fire Protection Association (NFPA):
3.  Article 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

F.  Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
1.  TSB95 - Additional Transmission Performance Guidelines for 4-pair 100 W Category 5 Cabling.
2. 568-A - Additional Transmission Performance Specifications for 4-pair 100 W Enhanced Category 5 Cabling.

G. Underwriter's Laboratories Inc., (UL):
   2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-fiber Members.
   5. 1569 - Standard for Metal-Clad Cables.
   7. 2225 - Metal-Clad Cables and Cable-Sealing Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Definitions of Terms and Other Electrical Considerations as Set Forth in the:
   1. Insulated Cable Engineering Association (ICEA).
   2. American Society of Testing Materials (ASTM)

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

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

B. Product Data:
   1. Manufacturer of Wire and Cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. American Wire Gauge size.
   4. Conductor material.
   5. Pulling compounds.
   6. LAN cable test form.

C. Shop Drawings:
   1. Show splice locations.

D. Test Reports:
   1. Submit test reports for meg-ohm tests.
   2. LAN Cable Test Reports:
      a. Submit 3 copies of test reports showing the results of all tests specified herein or in Section 16950:
         1) Test type.
         2) Test location.
         3) Test date.
         4) Cable number.
         5) Cable length.
6) Certification that the cable meets or exceeds the specified standard.
   b. Furnish hard copy and electronic copy for all traces.

E. Calculations:
   1. Submit cable pulling calculations for all cables larger than 2/0 AWG and pulling
      lengths longer than 200 feet.
   2. Submit cable pulling calculations for all conductor sizes for pulling lengths
      longer than 500 feet.
   3. Submit the calculations to the ENGINEER a minimum of 2 weeks before the
      cable pull.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 WARRANTY

A. Refer to Section 16050.

1.09 SYSTEM START-UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. 600 Volt Class Wire and Cable:
      a. General Cable.
      b. Okonite Company.
      c. Southwire Company.
   2. Instrumentation Class Wire and Cable:
      a. Alpha Wire Company.
      b. Belden CDT.
      c. General Cable BICC Brand.
      d. Okonite Company.
      e. Rockbestos Surprenant Cable Corporation.
   3. Network Cables:
      a. Belden CDT.
      b. General Cable.
      c. Lucent.
   4. Fire Alarm Wire and Cable:
      a. West Penn Wire.
      b. Olympic Wire and Cable.
      c. Rockbestos Surprenant Cable Corporation.
2.02 MATERIALS

A. Conductors:
   1. Copper per ASTM B 3.
   2. Minimum 97 percent conductivity.

2.03 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of
delivery to the site.
   2. Permanently mark each wire and cable with the following at 24 inch intervals:
      a. American Wire Gauge (AWG) size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer's name.
   3. Identify and Mark Wire and Cable as Specified in Section 16075:
      a. Use integral color insulation for Number 2 AWG and smaller wire.
      b. Wrap colored tape around cable larger than Number 2 AWG.

B. 600 Volt Class Wire and Cable:
   1. Provide American Wire Gauge (AWG) or kcmil sizes as indicated on the
      Drawings or in the Conduit Schedules:
      a. When Not Indicated on the Drawings, Size Wire as Follows:
         1) In Accordance with the National Electrical Code:
            a) Use 75 degree Celsius ampacity ratings.
            b) Ampacity rating after all derating factors, equal to or greater than
               rating of the overcurrent device.
         2) Provide Number 12 AWG minimum for power conductors.
         3) Provide Number 14 AWG minimum for control conductors.
   2. Provide Class B Stranding Per ASTM B 8:
      a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
   a. XHHW-2.
   b. Ninety degree Celsius rating in wet or dry locations.

4. Multiconductor Cables:
   a. Number and size of conductors as indicated on the Drawings or in the
      Conduit Schedules.
   b. Individual conductors with XHHW-2 insulation.
   c. Overall PVC jacket.
   d. Tray Cable rated.
   e. Color-coding for control wire per ICEA Method 1, E-2.
   f. Ground Conductor: Insulated, green:
      1) Sized per NEC.

C. Instrumentation Class Cable:
   1. Type TC.
   2. Suitable for use in wet locations.
   4. Temperature Rating: 90 degrees Celsius wet or dry location.
   5. Conductors:
      a. Insulation:
         1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket
            4 mils nominal thickness.
      b. Number 16 AWG stranded and tinned.
      c. Color Code:
         1) Pair: Black and white.
         2) Triad: Black, white and red.
         3) Multiple Pairs or Triads:
            a) Color-coded and numbered.
   6. Drain Wire:
      a. Eighteen AWG.
      b. Stranded, tinned.
   7. Jacket:
      a. Flame retardant, moisture and sunlight resistant PVC.
      b. Ripcord laid longitudinally under jacket to facilitate removal.
   8. Shielding:
      a. Individual Pair/Triad:
         1) Minimum 1.35-mil double-faced aluminum foil/polyester tape
            overlapped to provide 100 percent coverage.
      b. Multiple Pair or Triad Shielding:
         1) Group Shield: Minimum 1.35-mil double-faced aluminum
            foil/polyester tape overlapped to provide 100 percent coverage.
         2) Completely isolate group shields from each other.
         3) Cable Shield: 2.35 mils double-faced aluminum and synthetic
            polymer backed tape overlapped to provide 100 percent coverage.
      c. All shielding to be in contact with the drain wire.

D. Network Cables:
   1. Category 5e:
      a. Conductors:
         1) Twenty-four AWG solid bare annealed copper.
      b. Insulation:
         1) Polyolefin.
2) Four twisted pairs.

c. Color Code:
1) Pair 1: Blue-Blue/White.
2) Pair 2: Orange-Orange/White.
3) Pair 3: Green-Green/White.

d. Outer Jacket:
1) PVC with ripcord.

e. Electrical Characteristics:
1) Frequency Range: 1-100 MHz.
2) Attenuation: 24 dB.
3) Near-End Crosstalk (NEXT): 30.1 dB.
4) Power Sum NEXT: 27.1 dB.
5) Attenuation to Crosstalk Ratio: 6.1 dB.
6) Equal Level Far-End Crosstalk (ELFEXT): 17.4 dB.
7) Power-Sum ELFEXT: 14.4 dB.
8) Return Loss: 10 dB.
9) Propagation Delay: 548 nanoseconds.
10) Delay Skew: 50 nanoseconds.

E. Fire Alarm Cable:
1. Number of Pairs: As indicated on the Drawings or as necessary for the application.
2. Voltage Rating: 300V minimum.
3. Two-hour fire rating per UL 2196.
4. Provide Type FPLP (power-limited plenum rated) for all cabling within ducts, plenums, and all spaces used for air handling:
   a. Cable must meet NEC standards, and must have adequate fire-resistant and low smoke-producing characteristics.
5. Provide Type FPLR (power-limited riser rated) for all vertical runs that pass from floor to floor:
   a. FPLR cable must meet NEC standards, and must have fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.
6. FPL (power-limited general purpose) is only suitable for general-purpose fire alarm use and shall not be used for risers, ducts, plenums, and in air-handling spaces:
   a. FPL cable must meet NEC standards, and must be listed as resistant to the spread of fire.
7. Cable substitutions are not permitted unless approved by ENGINEER.
9. Conductor Insulation:
   a. Low smoke PVC.
   b. Minimum 105 degrees Celsius rating.
10. Conductor Jacket:
    a. Low smoke PVC.
    b. Ripcord and surface-printed with year of manufacture and cable description at maximum 24 inch intervals.
    c. Minimum 105 degrees Celsius rating.

F. Telephone Cable:
1. Number of Twisted Pairs: as indicated on the Drawings.
2. Voltage Rating: 300 volts.
3. Insulation: Thermoplastic, color coded in accordance with telephone industry standards Section 16075.
4. Insulation:
   b. Plenum-rated: FEP.
5. Jacket:
   a. Non-Plenum: PVC.
   b. Plenum-Rated: Low smoke PVC.
   c. Surface-printed with year of manufacture and cable description at maximum 24 inch intervals.
6. Shield: 8 mil aluminum or copper, overlapped to provide 100 percent coverage, covered totally on both sides with copolymer or equal coating able to provide an effective moisture barrier.
7. Conductors: ASTM B3, solid, soft, bare copper.
8. Use minimum Number 22 AWG conductors, unless otherwise indicated on the Drawings.
9. Twist insulated conductors into pairs with varying lengths of lay.
10. Apply non-hygroscopic core tape over cable core as a dielectric and heat barrier.
11. Provide plenum-rated cable for wiring within ducts, plenums, and all spaces used for air handling.

2.04 ACCESSORIES

A. Wire Ties:
   1. One of the Following or Equal:
      a. T&B "Ty-Rap" cable ties.
      b. Panduit cable ties.

B. Wire Markers:
   1. Reference Section 16075.

2.05 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirement of ICEA Publication No. S-68-516.

B. Test type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Color-Coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for all 240/120 Volt and 208/120 Volt systems:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Phase C - Blue.
d. Single Phase System - Black for one hot leg, red for the other.
e. Neutral - White.
f. High Phase or Wild Leg - Orange.
g. Equipment Ground - Green.

3. The Following Color Code shall be Followed for All 480/277 Volt Systems:
   a. Phase A - Brown.
   b. Phase B - Orange.
   c. Phase C - Yellow.
   d. Neutral - Gray.
   e. Equipment Ground - Green.

4. The Following Color Code shall be Followed for All 120 VAC Control Wiring:
   a. Power - Red.
   b. Neutral - White.

5. The following color code shall be followed for all general purpose DC control circuits:
   b. Positive - Pink.

6. Switch legs shall be violet. Three-way switch runners shall be pink.

7. Wires in intrinsically safe circuits shall be light blue.

8. Wire Colors shall be Implemented in the Following Methods:
   a. Wires manufactured of the desired color.
   b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits:
   1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
      a. Ideal Products.
      b. Polywater Products.
      c. 3M Products.
      d. Greenlee Products.
      e. Or equal as recommended by cable manufacturer.
      f. Do not use oil, grease or similar substances.

E. Cable Pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables Number 1 AWG and smaller, install cables by hand.
   3. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
   4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the ENGINEER may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.

6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
   a. Make splices in manholes or pull boxes only.
   b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

G. Install and terminate all wire in accordance with manufacturer’s recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
   1. Do not lace wires in gutter or panel channel.
   2. Install all wire ties with a flush cutting wire tie installation tool:
      a. Use a tool with an adjustable tension setting.
   3. Do not leave sharp edges on wire ties.

I. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head:
   1. Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.
   2. Do not use crimp lugs on solid wire.

J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

K. Splices:
   1. Provide continuous circuits from origin to termination whenever possible:
      a. Obtain ENGINEER’s approval prior to making any splices.
   2. Lighting and receptacle circuit conductors may be spliced without prior approval from the ENGINEER.
   3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
      a. Refer to Section 16050 for box NEMA rating requirements.
      b. Make splices in labeled junction boxes for power conductors.
      c. Make Splices for Control and Instrument Conductors in Terminal Boxes:
         1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
   4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
   5. Clearly label junction and terminal boxes containing splices with the word "SPICE."
   6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
   7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
      a. In NEMA 4 or NEMA 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
   a) A heat shrink insulating system listed for submersible applications.
   b) Or an epoxy resin splicing kit.

L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

M. Instrumentation Class Cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Refer to Section 16050 for shield grounding requirements.

N. Multi-Conductor Cable:
   1. Where cable is not routed in conduit with a separate ground conductor, use one conductor in the cable as a ground conductor:
      a) Use an internal ground conductor, if it is no smaller than as indicated on the Drawings, and meets NEC requirements for equipment ground conductor size.
      b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.

O. Armored Cable:
   1. Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with 1 of the full-sized conductors serving as ground.
   2. The cable armor is not acceptable as a ground conductor.
   3. Where armored cable terminates at a device, switchboard, panel, etc., use armored cable connector.
   4. Where armored cable run continues in conduit, strip jacket and armor for portions in conduit, and terminate cable and jacket with an armored cable connector threaded into a coupling or conduit box.

P. Telephone cable:
   1. Install telephone cables in dedicated metallic raceways, including raceways in ductbanks, manholes, and pull boxes.

Q. Fire alarm cable:
   1. Install fire alarm cable in dedicated metallic raceways as indicated on the Drawings.

R. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
S. Submersible Cable in Wet Wells:
   1. Provide Kellem’s grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

T. Wiring Allowances:
   1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
   2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. LAN Cable Testing:
   1. Test Plan and Witnessing:
      a. Obtain ENGINEER’S approval for the test procedures as part of the submittal process.
      b. Arrange for the ENGINEER to witness all testing.
   2. Submit a request for witness 15 days (minimum) before the proposed test date.
   3. Pre-Testing:
      a. Test Individual Cables before Installation:
         1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
         2) Before the cable is installed, verify that the cable conforms to the Manufacturer’s attenuation specification and that no damage has been done to the cable during shipping or handling.
         3) The test shall be fully documented and the results submitted to the ENGINEER, including a hard copy of all traces, before placement of the cable.
         4) The ENGINEER shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the ENGINEER.
   4. Test Equipment:
      a. LAN Certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
         1) Near End Cross Talk.
         2) Attenuation.
         3) Equal Level Far End Cross Talk.
         4) Return Loss.
         5) Ambient Noise.
         6) Effective Cable Length.
         7) Propagation Delay.
         8) Continuity/Loop Resistance.
      b. LAN certification test equipment shall be able to store and produce plots of the test results.
c. Manufacturers - One of the following:
   2) Approved equal.

C. Grounding:
   1. Refer to Section 16060.

3.03 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16130

CONDUITS

PART 1      GENERAL

1.01       SUMMARY

A. Section Includes Requirements for:
   1. Metallic Conduits:
      a. Rigid Galvanized Steel (GRC).
      b. Intermediate Metallic Conduit (IMC).
      c. Polyvinyl Chloride Coated Metallic (Steel - PCS).
      d. Flexible Steel. (FLX).
      e. Liquid-Tight Flexible Metal Conduit (SLT).
   2. Nonmetallic Conduits:
      a. Rigid Nonmetallic (PVC).
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

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

1.02       REFERENCES

A. Refer to Section 16050.

B. American National Standards Institute (ANSI):
   1. C80.1 - Rigid Steel Conduit - Zinc Coated.
   2. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer's Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel
      Conduit and Intermediate Steel Conduit.
   2. TC2 - Electrical Plastic Tubing and Conduit.
   3. TC3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

D. Underwriters Laboratories (UL):
   1. 1 - Standard for Safety for Flexible Metal Conduit.
   2. 6 - Standard for Safety for Rigid Metal Conduit.
   6. 94VO - Standard for Vertical Flame Test.

1.03       DEFINITIONS

A. Refer to Section 16050.
B. Specific Definitions and Abbreviations:
1. **Conduit Bodies**: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to: shapes C, E, LB, T, X, etc.
2. **Conduit Fitting**: An accessory that serves primarily a mechanical purpose. Includes, but not limited to: bushings, locknuts, hubs, couplings, reducers, etc.
3. **GRC**: Galvanized Rigid Steel Conduit.
4. **PCS**: PVC Coated Rigid Steel Conduit.
5. **Intermediate Metallic Conduit.**
6. **PVC**: Polyvinyl Chloride Rigid Nonmetallic Conduit.
8. **FLX**: Flexible Metallic Conduit.
9. **NFC**: Nonmetallic Flexible Conduit.
10. **NPT**: National Pipe Thread.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

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

B. **Product Data:**
   1. Furnish complete manufacturer’s catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the project.
   2. Furnish complete manufacturer’s recommended special tools to be used for installation if required.
   3. Certified test results for PVC coated metallic conduit showing the adhesive band is stronger than the tensile strength of the PVC.

C. **Record Documents:**
   1. Incorporate all changes in conduit routing on conduit Drawings.
   2. Dimension underground and concealed conduits from building lines.

D. **Installation Drawings**: Installation drawings, including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PVC coated Rigid Steel (PCS) conduits shall be certified by the manufacturer for installation of the conduit.
1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

B. Do not expose type PVC to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

A. Refer to Section 16050.

1.11 SYSTEM START-UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized Rigid Steel Conduit (GRC):
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.

B. Polyvinyl Chloride-Coated Rigid Steel Conduit (PCS):
   1. One of the following or equal:
      a. Robroy Industries.
      b. OCAL, Inc.
      c. Perma Kote.

C. Sealtight Liquid-Tight Flexible Conduit (SLT):
   1. One of the following or equal:
      a. ALFLEX (Southwire).
      b. AFC Cable Systems.
      c. Electriflex.
      d. Anaconda.
D. Rigid Nonmetallic Polyvinyl Chloride Conduit (PVC):
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.

E. Conduit Bodies:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z / Gedney.
      d. Ocal.
      e. Robroy.
      f. Carlon.

F. Galvanized Rigid Steel Conduit Expansion Fittings:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z/Gedney.

G. Conduit Sleeve:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z/Gedney.

H. Conduit Seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

I. Conduit Mounting Strut:
   1. One of the following or equal:
      a. Unistrut.
      b. Globe Strut.
      c. B-Line Strut.

J. Conduit Thruwall Seals:
   1. The following or equal:
      a. O-Z/Gedney, Type "WSK."

2.02 COMPONENTS

A. Galvanized Rigid Steel Conduit and Couplings (GRC):
   1. All Threads: NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
   a. UL6.
   b. ANSI C801.

B. PVC Coated Steel Conduit and Conduit Bodies (PCS):
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
   2. Coated Conduit Conforms to NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory Bonded PVC Jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.
      c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
      d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduit having areas with thin or no coating are not acceptable.
      c. All threads shall be coated with urethane.
   5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS Conduit Bodies:
      a. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
      b. The PVC Coating on the outside of conduit bodies shall be 0.040 inches thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
      c. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.

C. Flexible Metallic Conduit (FLX):
   1. Materials:
      b. Single strip steel hot-dip galvanized on all 4 sides before conduit fabrication.
      c. Full Wall:
         1) Reduced wall thickness not allowed.
   2. Interlocking design formed from continuous metal strip for integrity and flexibility.
   3. UL Conduits through Penetration Fire Wall Rating:
      a. Three-hour rated for steel.
      b. Two-hour rated for aluminum.
   4. UL rated for Cable Tray and Environmental Air-Handling Space requirements.
D. Liquid-Tight Flexible Metallic Conduit (SLT):
1. Temperature rated for use in the ambient temperature at the installed location
   but not less than the following:
   a. General Purpose:
      1) Temperature range –20 degrees Celsius to +80 degrees Celsius.
   b. Oil Resistant:
      1) Temperature range -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot dip galvanized on all 4 sides before
   conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for
   easy wire pulling.
5. Overall polyvinyl chloride jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes
   1/2-inch through 1-1/4-inch.

E. Rigid Nonmetallic Polyvinyl Chloride Conduit (PVC):
1. Extruded from Virgin Polyvinyl Chloride Compound:
   a. Schedule 40 unless otherwise indicated.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

F. Conduit Bodies:
1. Material Consistent with Conduit Type:
   a. Malleable iron bodies and covers when used with type GRC conduit.
   b. Cast aluminum bodies and covers when used with type RAC.
   c. PVC bodies and covers when used with type PVC.
   d. PVC coated malleable iron bodies and covers when used with type PCS.
2. Conduit Bodies to Conform to Form 8, Mark 9, or Mogul Design:
   a. Mogul design conforming to NEC requirements for bending space for
      large conductors for conduit trade sizes of 1 inch and larger with
      conductors #4 AWG and larger, or where required for wire bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to
   threaded holes in conduit body.
4. PVC Coated Malleable Iron Conduit Bodies and Covers:
   a. Bodies before coating shall meet requirements for malleable iron conduit
      bodies.
   b. 0.040-inch exterior PVC coating and 0.002 inch interior urethane coating
      as required for type PCS conduit and fittings.
   c. Utilize the PVC coating as an integral part of the gasket design.
   d. Stainless steel cover screws heads shall be encapsulated with plastic to
      assure corrosion protection.

2.03 ACCESSORIES

A. Connectors and Fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated Throat Metallic Bushings:
1. Construction:
   a. Malleable iron or zinc plated steel when used with steel conduit.
   b. Positive metallic conduit end stop.
c. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
d. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated Grounding Bushings:
   1. Construction:
      a. Malleable iron or steel, zinc plated, with a positive metallic end stop.
      b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
      c. Tin plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical Unions (Erickson Couplings):
   1. Construction:
      a. Malleable iron for use with steel conduit.
      b. Concrete tight, 3-piece construction.
      c. Rated for Class I Division 1 Group D in hazardous areas.

E. PVC Coated Rigid Steel Conduit (PCS) Fittings:
   1. All hollow conduit fittings, which serve, as part of the PCS conduit system must be coated with an exterior PVC coating and interior urethane coating as described for the conduit.
   2. The conduit fitting, before coating, shall be new, unused material and shall conform to appropriate UL standards.
   3. A PVC sleeve extending 1 pipe diameter or 2 inches, whichever is less, shall be formed at every female conduit opening on fittings except unions:
      a. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
   4. Flexible overlapping sleeves on all hubs and couplings shall provide a vapor and moisture tight seal at every connection.

F. Flexible Metallic Conduit (FLX) Fittings:
   1. Provide insulated die-cast connectors with ridges that thread into the inside of the conduit to achieve a force fit.
   2. Binding screw connectors are not acceptable.

G. Sealtight - Liquid-Tight Flexible Conduit (SLT) Fittings:
   1. Construction:
      a. Malleable iron hot dip galvanized.
      b. Furnished with locknut and sealing ring.
      c. Liquid-tight, rain-tight, oil-tight.
      d. Insulated throat.
      e. Furnish as straight, 45 degree elbows and 90 degree elbows.
      f. Designed to Prevent Sleeving:
         1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
      g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device if inserted into raceway and directly in contact with conductors shall have rolled over edges for sizes under 5 inches.
h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.

H. Outdoor Sealtight - Liquid-Tight Flexible Conduit (SLT) Fittings:
   1. Construction:
      a. PVC coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
      b. Connectors shall have an insulated throat and an integral sealing ring.

I. Hubs for Threaded Attachment of Steel Conduit to Sheet Metal Enclosures:
   1. Construction:
      a. Shall have an insulated throat.
      b. When used in corrosive areas shall be PVC coated.
      c. Bonding locknut.
      d. Recessed neoprene O-ring to assure watertight and dust tight connector.
      e. One half-inch through 1-1/4-inch steel zinc electroplated.
      f. One and one half-inch through 6-inch malleable iron zinc plated.
   2. Usage:
      a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

J. Sealing Fittings:
   1. Construction:
      a. Forty percent wire fill capacity.
      b. PVC coated when used in corrosive areas.
      c. Malleable ductile iron with steel conduit.
      d. Crouse-Hinds Type EYD where drains are required.
      e. Crouse-Hinds Type EYS where drains are not required.

K. PVC Fittings:
   1. Shall include the following:
      a. Couplings.
      b. Terminal Adapters.
      c. Female Adapters.
      d. Caps.
      e. Reducer Bushings.
      f. Duct Couplings.
      g. End Bells.
      h. Expansion Couplings.
      i. Duct Couplings 5 degree.
      j. C - Pull Fittings.
      k. E - Pull Fittings.
      l. LB -Pull Fittings.
      m. LL - Pull Fittings.
      n. LR - Pull Fittings.
      o. T – Pull Fittings.
      p. X - Pull Fittings.
      q. Service Entrance Caps.
2. Materials:
   a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
   b. All metal hardware shall be stainless steel.

L. Through Wall and Floor Seals:
   1. Materials:
      a. Body - casting of malleable or ductile iron with a hot dip galvanized finish.
      b. Grommet - neoprene.
      c. Pressure rings - PVC coated steel.
      d. Disc material - PVC coated steel.
      e. Aluminum when used with conduit type RAC.

M. Expansion/Deflection Couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends that they connect.
   2. Shall allow movement of 3/4-inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings – Bronze or galvanized ductile iron.
      b. Sleeve - Neoprene.
      c. Bands - Stainless Steel.
      d. Bonding Jumper - Tinned copper braid.
   6. These fittings shall be constructed in such a manner that will provide the continuity of the ground path in each conduit or raceway.

N. Expansion Couplings:
   1. Shall Allow for Expansion and Contraction of Conduit:
      a. Permitting 8-inch movement, 4 inches in either direction.
   2. Constructed to maintain electrical continuity of the conduit system.
   3. Materials:
      a. Head - Malleable or ductile iron.
      b. Sleeve - Steel.
      c. Insulating Bushing - Phenolic.
      d. Finish - Hot dip galvanized.
      e. Aluminum when used with conduit type RAC.
   4. These fittings shall be constructed in such a manner that will provide the continuity of the ground path in each conduit or raceway.

O. Conduit Markers:
   1. In accordance with Section 16075.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 16050.
PART 3   EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. General:
   1. Conduit Routing:
      a. The Electrical Drawings are Diagrammatic in Nature:
         1) Install conduit runs in accordance with schematic representation indicated on the Drawings and as specified.
         2) Modify conduit runs to suit field conditions, as accepted by the ENGINEER:
            a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
            b) Make changes in conduit routing due to the relocation of electrical equipment.
      b. The CONTRACTOR is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the ENGINEER:
         1) The ENGINEER is the sole source in determining whether the change is constituted as a deviation:
         2) Perform any changes resulting in additional conduits, or extra work from such deviations.
         3) Incorporate any deviations on the Record Documents.
      c. OWNER reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on Record Drawings.
   2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
   3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
      a. Clearances of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
      b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.
      c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
      d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
   4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
      a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
   5. Do not install 1 inch or larger conduits in or through structural members unless approved by the ENGINEER.
   6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
b. Make changes in direction with long radius bends or with conduit bodies.

7. Route all exposed conduit to preserve headroom, access space and work space and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and not block or interfere with ingress or egress, including equipment removal hatches.
   b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.

8. Conduit may be run in concrete members or slabs with permission of the ENGINEER, provided the outside diameter does not exceed 1/3 the thickness of the concrete:
   a. Locate conduit in the center of the concrete or where the minimum concrete cover will be 1 conduit diameter.
   b. Space conduits at least 3 diameters apart on centers.
   c. As a general rule, conduit may not cross other conduit or pipe in concrete members or slabs.

9. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables etc.

10. Conduit Runs between Pull Boxes or Junction Boxes:
    a. Total bends equaling not more than 270 degrees.
    b. Install NEC required pull boxes at locations acceptable to the ENGINEER.
    c. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.

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

12. For existing and new 2 inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
    a. Remove and replace conduits through which mandrel will not pass.

13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically shown on the Drawings.

14. Install complete conduit systems before conductors are installed.

15. Provide metallic conduits terminating in transformer switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with, a minimum No. 6 AWG ground wire.

16. Underground and Embedded Conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete reinforced duct bank construction:
       1) Refer to Section 16133.
    b. Make underground conduit size transitions at pullboxes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and pullboxes.

C. Lighting and Receptacle Conduits:
   1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
a. Minimum Conduit Size:
   1) Three fourth inch for exposed conduits.
   2) One inch for underground or in slab conduits.
2. Provide conduit materials for the installed location as specified in Section 16050.

D. Conduit Usage:
1. Exposed Conduits:
   a. Rigid Conduit:
      1) Install the rigid conduit type for each location as specified in Section 16050 and indicated in the Conduit Schedule.
      2) Minimum Size: 3/4-inch.
   b. Flexible Conduit:
      1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:
         a) Use type SLT with rigid metallic conduit.
         b) Use type NFC with PVC conduit.
      2) Minimum Size: 3/4-inch:
         a) One half-inch when required for connection to instruments.
      3) Maximum Length: 36 inches.
2. Underground and Embedded Conduits:
   a. Type PVC Schedule 40 and PCS as Specified below:
      1) Use Type PCS in underground and embedded installation as follows:
         a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
         b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished floor.
         c) For any and all bends where the total deflection is greater then 45 degrees.
   b. Minimum Size:
      1) Two-inch in duct banks unless otherwise indicated.
      2) One-inch for in slab conduits unless otherwise indicated.
3. PVC Coated Rigid Metallic Conduit (PCS):
   a. Use specifically manufactured or machined threading dies to manufacturer’s specifications to accommodate the PVC jacket.
4. Galvanized Rigid Steel Conduit (GRC):
   a. Conduit shall be cut square and reamed before threading.
5. Nonmetallic Conduit (PVC):
   a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
   b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box. Use a locknut on the inside of the box to tighten the adapter to the box.
   c. Route Conduit to Afford it the Maximum Physical Protection:
      1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames:
         a) Use Schedule 80 where exposed runs may be subject to physical damage.
E.  Conduit Joints and Bends:

1. General:
   a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA 4 or NEMA 4X locations, make joints liquid-tight.
   b. Keep bends and offsets in conduit runs to an absolute minimum.
   c. All bends shall be symmetrical.
   d. The Following Conduit Systems shall use Large Radius Sweep Elbows:
      1) Underground conduits.
      2) Conduits containing medium voltage cables.
      3) Conduits containing shielded cables.
      4) Conduits containing fiber optic cables.
   e. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
   f. Make field bends with a radius of not less than the requirements found in the NEC:
      1) The minimum bending radius of the cable must be greater than the radius of the conduit bend.
      2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
         a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
         b) For the serving utilities, make bends to meet their requirements.
   g. Replace all deformed, flattened, or kinked conduit.

2. Threaded Conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar" or CRC "Zinc It."
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit.
      2) Apply to the male threads and tighten joints securely.
      3) Clean excess sealant from exposed threads after assembly.
   f. Securely tighten all threaded connections.
   g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. Nonmetallic (PVC):
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends:
      1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.
F. Conduit Sealing and Drainage:
1. Conduit drainage and sealing other than required for hazardous and classified areas:
   a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enter buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
   b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.
   c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
      1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
   d. Provide conduit seals similar to O/Z Gedney (Type CSB series) on all conduits between corrosive and non-corrosive areas.
   e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at all control panels, junction boxes, pullboxes, low points of conduit, or any place where moisture may condense and accumulate:
   a. Provide Crouse-Hinds Type EYD or approved equal, where drains are required.
   b. Provide Crouse-Hinds Type EYS or approved equal, where drains are not required.

G. Conduit Supports:
1. General:
   a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
      1) Provide support materials consistent with the type of conduit being installed:
         a) Hot-dipped Galvanized steel for type GRC.
         b) Stainless steel for types PCS.
         c) Nonmetallic or epoxy coated for Type PVC.
   b. Support conduit at the intervals required by the National Electrical Code.
   c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Conduit on Concrete or Masonry:
   a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
   b. Use preset inserts in concrete when possible.
   c. Use pipe spacers (clamp backs) in wet locations.
   d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
3. Conduit on Metal Decking:
   a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet metal screws. Fully or partially hammer-driven screws are not acceptable.
4. Supports at Structural Steel Members:
   a. Use beam clamps.
   b. Drilling or welding may be used only as indicated or with approval of the ENGINEER.
5. PVC Coated Rigid Steel Conduit (PCS) Systems:
a. Provide right angle beam clamps and U-bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC encapsulated nuts that cover the exposed portions of the threads.
b. Securely fasten exposed PCS conduits with Type 316 stainless steel clamps or straps or PVC coated clamps or straps manufactured and supplied by the PCS conduit supplier.

H. Expansion or Expansion/Deflection Fittings:
   1. General:
      a. Align expansion coupling with the conduit run to prevent binding.
      b. Follow manufacturer’s instructions to set the piston opening.
      c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      d. Furnish fittings of the same material as the conduit system.
   2. For metallic conduit (PCS, GRC and RAC) provide expansion or expansion/deflection couplings, as appropriate, where:
      a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
   3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
      a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
      b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

I. Empty Conduits:
   1. Provide a polyethylene rope rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.
   2. Provide one empty 3/4-inch conduit for each four spare unused circuits or spaces of each flush mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable future branch circuits' extensions.
   3. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:
      a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:
   1. Provide flashings and counter flashings or pitch pockets for waterproofing of raceways, outlets, fittings, and other items that penetrate the roof.
   2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
      a. Running threads and threadless couplings are not allowed.
   3. Paint all exposed conduits in the process areas with a high quality epoxy based paint, unless otherwise directed by the ENGINEER.
   4. Replace any conduit installed that the ENGINEER determines does not meet the requirements of this Specification.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.
3.03 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16133

DUCT BANKS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Electrical underground duct banks.
   2. Duct spacing and terminations.
   4. Excavation and patching.
   5. Coordination with other underground utilities.
   6. Concrete.

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

1.02 REFERENCES

A. Refer to Section 16050.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

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

B. Product Data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.

C. Provide Applicable Submittal Documents as Required in:
   1. Section 03200.
   2. Section 03300.
   3. Section 02318.
D. Shop Drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE
   A. Refer to Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
   A. Refer to Section 16050.

1.09 WARRANTY
   A. Refer to Section 16050.

1.10 SYSTEM STARTUP
   A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Conduit Spacers:
      1. One of the Following or equal:
         b. Cantex.
         c. Osburn Associates, Inc.

   B. Detectable Underground Marking Tape:
      1. One of the Following or equal:
         b. Brady - Identi-line.
         c. Thomas and Betts - Protect-A-Line.
         d. Panduit - Underground Hazard Tape.

   C. Pull Line:
      1. One of the Following or equal
         a. Arnco.
         b. Greenlee.
         c. Osburn Associates, Inc.

2.02 MATERIALS
   A. For Conduit Requirements, Reference Section 16130:
      1. Use duct suitable for use with 90 degree Celsius rated conductors.
B. Use minimum Number 4 reinforcing steel.

2.03 MANUFACTURED UNITS

A. Conduit Spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or listed above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking Type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   7. Accommodates 2 inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull Line:
   1. Minimum 1/4 inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.
   4. Sequential footage markings.

C. Detectable Marking Tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyester.
   3. Six-inch wide Red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."

2.04 MIXES

A. Refer to Section 03300 for concrete mixes requirements.

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Duct Banks:
   1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage Minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system in accordance with the Drawings and every 20 feet to steel reinforcing bar.
5. Install Watertight Underground Ducts:
   a. Slope duct banks away from buildings to pull boxes.
   b. Slope duct banks uniformly from pull boxes to pull boxes or both ways from high points between pull boxes.
   c. Slope a minimum of 1/2 inch per 10 feet.
6. Where new duct banks join to existing pull boxes make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
7. Install Pull Line in Spare Conduits:
   a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
   b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
1. Refer to Section 02318 for complete trenching requirements.
2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
3. Whenever possible, use the walls of the trench as forms for concrete encasement:
   a. Forms are required where the soil is not self-supporting.
4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct Spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 1.5 inches:
   a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8 foot maximum intervals:
   a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers with the duct bank:
      1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
         a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers Should Not Be Located at the Center of a Bend:
   a. Locate spacer in the tangent, free of the coupling on fabricated bends.
   b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
F. Concrete:
1. Refer to Section 03300 for concrete installation requirements.
2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
   a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking Tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For Conduit Installations Beneath Building Slabs:
1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
   a. Concrete for encasement under building slabs need not be colored red.
   b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.
   c. Where duct banks enter through building walls, foundation walls, stem walls, etc. the duct banks shall be doweled into the structure in such a manner as to prevent differential movement between the duct bank and the structure.
   d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

I. Restore all surfaces to their original condition per Section 02952, unless otherwise specified.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.04 PROTECTION

A. Refer to Section 16050.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION
SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Device boxes.
   2. Raceway system boxes.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. FB1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
   2. OS1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   3. OS2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.

C. Underwriters Laboratory:
   1. UL Standard 498 and 514.

D. Federal Specification No. W-C-586B.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions:
   1. Arcing Parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway System Boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.
B. Provide boxes and conduit bodies as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

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

B. Product Data:
   1. Manufacturer.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA Rating.
   4. Conduit entry locations.
   5. Catalog cut sheets.
   6. Installation instructions.

C. Shop Drawings:
   1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Regulatory Requirements:
   1. Outlet Boxes shall Comply with All Applicable Standards of:
      c. Underwriters Laboratories.
      d. Joint Industry Conference.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 SEQUENCING

A. Refer to Section 16050.

1.10 WARRANTY

A. Refer to Section 16050.

1.11 SYSTEM START UP

A. Refer to Section 16050.
PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following or equal:
1. Pressed Steel Boxes:
   a. Steel City.
   b. Appleton.
   c. Crouse - Hinds.
   d. Thomas & Betts.
2. Plastic and/or Fiberglass Boxes:
   a. Hoffman.
   b. Carlon.
   c. Stahlin.
3. Plastic Coated Steel Boxes:
   a. Rob Roy.
   b. OCAL.
4. Cast Device Boxes:
   a. Appleton.
   b. Crouse - Hinds.
   c. OZ/Gedney.
5. In-Use Weatherproof Non-Metallic GFI Outlet Box and Cover:
   a. Carlon.
   b. Tay-Mac.
6. Formed Steel Enclosures:
   a. Hoffman.
   b. Thomas and Betts.
   c. Stahlin.
   d. Rittal.
7. Stainless Steel Enclosures:
   a. Hoffman.
   b. Stahlin.
   c. Rittal.
8. Pressed Steel Boxes and Concrete Boxes:
   a. Appleton.
   b. Steel City.
   c. Cooper/Crouse Hinds.
   d. OZ/Gedney.

2.02 MANUFACTURED UNITS

A. Pressed Steel Boxes:
   1. One-piece galvanized pressed steel.
   2. Knockout type boxes.
   3. Minimum size 4-inch square by 2-1/8-inch deep.

B. Concrete Boxes:
   1. For outlets and pull boxes in concrete construction.
   2. Pressed steel or cast construction, concrete tight.
   3. Knockout size range 1/2-inch to 1-inch.
   4. Depth as needed.
   5. Types:
a. Four-inch octagon.
b. Four-inch octagon ceiling boxes with hanging bars.
c. Gangable Masonry Boxes:
   1) 3 1/2-inch deep, 3-3/4-inch high, Length as Required:
      a) 2-1/2-inch deep boxes may be used where wall thickness
         precludes the use of the deeper boxes.
   2) With partitions as needed.

C. Threaded-Hub Boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit size range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Malleable Iron Boxes:
      a. Conforming to ASTM A47-77 Grade 32510.

D. Plastic Coated Threaded-Hub Boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit size range from 3/4-inch to 1-inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the
         interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

E. Boxes:
   1. NEMA 4X.
   2. Constructed of molded fiberglass reinforced polyester.
   3. Integral neoprene gasket on cover attached with an oil-resistant adhesive.
   4. Enclosures to have internal pads for mounting optional panels and terminal
      kits.
   5. Covers:
      a. Screw Cover Enclosures:
         1) Covers held in place with captive, stainless steel, or monel screws.
         2) Covers attached to body with internal zinc-plated steel hinges.
      b. Quick Release Latches Covers:
         1) Corrosion resistant fiberglass hinges.
         2) Spring loaded fiberglass latches with a monel or stainless steel bail
            attached with monel or stainless steel screws.
         3) With a 316 stainless steel padlock hasp.
   6. With external mounting feet.
   7. Meeting the Following Minimum Standards and Tests:
<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Value</th>
<th>ASTM Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength</td>
<td>12,000 PSI</td>
<td>D-790</td>
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<tr>
<td>Heat Distortion</td>
<td>400° Fahrenheit</td>
<td>D-648</td>
</tr>
<tr>
<td>Water Absorption (24 hrs)</td>
<td>0.5 percent</td>
<td>D-570</td>
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<tr>
<td>Tensile Strength</td>
<td>5000 PSI</td>
<td>D-651</td>
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<tr>
<td>Specific Gravity</td>
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<td>Flammability</td>
<td>94V-0</td>
<td>UL-94</td>
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<td>D-149</td>
</tr>
<tr>
<td>Arc Resistance</td>
<td>180 Second</td>
<td>D-495</td>
</tr>
</tbody>
</table>

F. Formed Steel Enclosures:
   1. Steel:
      a. NEMA 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. All seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around three sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene Door Gasket to Provide a Watertight, Dusttight, Oiltight Seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Internal Panels:
         1) With plated steel shoulder studs for mounting an internal panel.
         2) Steel internal panel.
      h. Provide large enclosures with door and body stiffeners for extra rigidity.
      i. No Holes or Knockouts.
      j. Finish:
         1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
         2) White electrostatically applied polyester powder mounting plate.
      k. Heavy gauge steel external mounting brackets when surface mounted.
   2. Stainless Steel:
      a. NEMA 4X:
         1) Boxes in Locations Subject to Flooding or Temporary Submersion:
      b. Fabricated from 14-gauge type 316 stainless steel.
      c. All seams continuously welded.
      d. Door:
         1) Rolled lip around three sides.
2) Attached to enclosure by means of a continuous stainless steel hinge and pin.

e. Neoprene Door Gasket to Provide a Watertight Seal:
   1) Attached with an adhesive.
   2) Retained by a retaining strip.

f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
   1) With a hasp and staple for padlocking.

g. Internal Panels:
   1) With stainless steel shoulder studs for mounting an internal panel.
   2) Stainless steel internal panel.

h. Provide large enclosures with door and body stiffeners for extra rigidity.

i. No holes or knockouts.

j. Finish:
   1) Brushed.

k. Stainless steel external mounting brackets when surface mounted.

G. Cast Iron Junction Boxes:
   1. NEMA 4.
   2. Recessed cover boxes.
   3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
   4. Designed for Flush Mounting in Walls or Floors:
      a. Can be surface mounted using mounting lugs.

5. Construction:
   a. Cast iron box.
   b. Covers:
      1) Checkered plate covers suitable for foot traffic.
      2) When used in areas subject to vehicular traffic H-20 loading.
   c. Hot dip galvanized.
   d. Neoprene gasket.
   e. Stainless steel screw covers.

2.03 ACCESSORIES

A. Fasteners:
   1. Electroplated or stainless steel in boxes with wiring devices.
   2. Screws, Nuts, Bolts, and Other Threaded Fasteners:
      a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. General:
   1. Provide materials and construction suitable for environmental conditions at the location of the box as indicated in Section 16050.
   2. Provide Outlet Box Materials to Match the Conduit System:
      a. GRC - Cast Ferrous Boxes.
b. PCS - PVC Coated Cast Ferrous Boxes.
c. PVC - PVC Boxes.
3. Solid Type Gang Boxes:
   a. For more than two devices.
   b. For barriered outlets.
4. Support all wall mounted NEMA 4 or NEMA 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
   a. Use machined spacers to maintain air space; built-up washers are not acceptable.
   b. Use stainless steel or nylon materials for spacers.
5. Use cast malleable iron boxes when box must support other devices.
6. Boxes Serving Luminaires or Devices:
   a. Use as pull boxes wherever possible.
7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120V discrete or power wiring.
9. Size boxes to meet NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet Boxes:
1. Locate Outlet Boxes as Indicated on the Drawings:
   a. Adjust locations so as not to conflict with structural requirements or other trades.
2. Use Deep Threaded-Hub Malleable Iron Boxes:
   a. Where exposed to the weather.
   b. In unheated areas.
   c. Where Subject to Mechanical Damage:
      1) Defined as exposed boxes less than 10 feet above the floor.
   d. To act as a pull box for conductors in a conduit system.
   e. Accommodate wiring devices.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA 4X area and when the conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

D. Pull Boxes and Junction Boxes:
1. Provide pull boxes as needed to facilitate wire pulling or whenever the total amount of bends in a conduit run exceeds 270 degrees.
2. Size pull boxes to meet NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
3. Install additional pull boxes as required to meet cable manufacturer’s pulling tension requirements.
4. Install pull boxes such that access to them is not restricted.

E. For Boxes Not Indicated:
1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050.
2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
   a. One-piece, galvanized, pressed steel.
3. Flush Mounting in Concrete:
   a. Deep, galvanized, pressed steel.
4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
   a. Cast ferrous boxes with mounting lugs, zinc, or cadmium plating finish.
5. Boxes for Concealed Conduit System:
   a. Non-Fire Rated Construction:
      1) Depth: To suit job conditions and comply with the NEC.
      2) For Luminaries: Use outlet boxes designed for the purpose:
         a) Fifty Pounds or Less: Box marked “FOR FIXTURE SUPPORT.”
         b) More than 50 Pounds: Box listed and marked with the weight of
            the fixture to be supported (or support luminaire independent of
            the box.)
      3) For Junction and Pull Boxes: use galvanized steel boxes with flush
         covers.
      4) For Switches, Receptacles, Etc:
         a) Cast-In-Place Concrete Walls: Use 4 inch or 4-11/16 inch
            galvanized steel boxes with device covers.
         b) Walls Other than Cast-In-Place Concrete: Use type of
            galvanized steel box which will allow wall plate to cover the
            opening made for the installation of the box.
6. Recessed boxes in fire rated (2 hour maximum) bearing and nonbearing wood
   or steel stud walls (gypsum wallboard facings):
   a. Use listed single and double gang metallic outlet and switch boxes. The
      surface area of individual outlet or switch boxes shall not exceed
      16 square inches.
   b. The aggregate surface area of the boxes shall not exceed 100 square
      inches per 100 square feet of wall surface.
   c. Securely fasten boxes to the studs. Verify that the opening in the
      wallboard facing is cut so that the clearance between the box and the
      wallboard does not exceed 1/8 inch.
   d. Separate boxes located on opposite sides of walls or partitions by a
      minimum horizontal distance of 24 inches. This minimum separation
      distance may be reduced when wall opening protective materials are
      installed according to the requirements of their classification.
   e. Use wall opening protective material in conjunction with boxes installed on
      opposite sides of walls or partitions of staggered stud construction in
      accordance with the classification requirements for the protective material.
7. Other Fire Rated Construction: Use materials and methods to comply with the
   listing requirements for the classified construction.

3.02 FIELD QUALITY CONTROL
   A. Refer to Section 16050.

3.03 CLEANING
   A. Refer to Section 16050.
3.04 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16135

PRECAST CONCRETE PULL BOXES AND ELECTRICAL MANHOLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Precast concrete electrical pullboxes, manholes, and vaults.
   2. Precast Concrete Electrical Manhole/Vault Accessories:
      a. Pulling eyes/irons.
      b. Cable racks.
      c. Covers.

1.02 REFERENCES

A. Refer to Section 16050.

B. American Association of State Highway Transportation Officials (AASHTO):

C. American National Standards Institute (ANSI):

D. American Society for Testing and Materials (ASTM):

E. National Precast Concrete Association (NPCA).

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Design, fabricate, and install precast concrete pull boxes and electrical manholes. Provide boxes and manholes of size and shape and with interior details as indicated on the Drawings and as specified herein.

B. Performance Requirements:
   1. Provide electrical manholes with watertight joints between sections, and with details to minimize water infiltration at duct bank and conduit penetrations.
   2. Provide electrical manholes that are watertight and free of water infiltration.
1.05 SUBMITTALS

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

B. Precast manufacturer’s qualifications.

C. Product Data: Manufacturer’s catalog data, details, and warranties for the following items:
   1. Precast Concrete Structures:
      a. Describe proposed inspection program during construction and provide names of qualified inspectors.
   3. Interior Appurtenances:
      a. Conduit and cable supports and racks.
      b. Pulling irons.
      c. Ladders and ladder accessories.
      d. Sump covers and cover supports.

D. Shop Drawings:
   1. Dimensioned plans and sections. Indicate size, location, and vertical elevation of duct bank windows and conduit penetrations. Include location and details of access openings, cable and conduit supports and racks, ladders, access openings, and sumps.
   2. Structure reinforcement. Indicate reinforcing steel sizes and spacing.

E. Design Data:
   1. Structural Calculations: A complete set of detailed structural design calculations:
      a. Stamped by a Professional Engineer licensed in the state where the project is being constructed.
   2. Concrete mix designs documenting that the mixes to be used conform to the requirements of this Section.

F. Record Data:
   1. Tests for compressive strength of concrete used in structures, in accordance with ASTM C858.
   2. Manufacturer’s inspection reports required by ASTM C1037.

G. Certificates:
   1. Manufacturer’s certification that precast electrical boxes and manholes conform to the requirements of ASTM C858.

H. Warranties.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Precast concrete boxes and electrical manholes shall comply with ASTM C858 and ANSI C2, except as modified herein:
   1. In the event of a conflict between referenced standards or between standards and Specification requirements, the more stringent requirements shall govern.
C. Precast Manufacturer Qualifications:
   1. Holding current Plant Certification by NPCA.
   2. Able to demonstrate at least 5 years experience in production and installation
      of products of the type required for this Work.
   3. Capable of providing structural designs prepared by a Professional Engineer
      licensed in the State where the project is being constructed.
   4. Capable of providing inspection during construction in accordance with the
      requirements of ASTM C1037.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

B. Packing, Shipping, Handling, and Unloading:
   1. Furnish crane or forklift for unloading of pull boxes and manholes.
   2. Manholes and pull boxes shall be adequately packaged and braced to avoid
      damage to sumps and ventilators.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 WARRANTY

A. Refer to Section 16050.

1.10 SYSTEM STARTUP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following or equal:
   1. Amcor.
   2. Oldcastle.

2.02 MANUFACTURED UNITS

A. Precast Concrete Pull Boxes and Electrical Manholes:
   1. General:
      a. Precast concrete structures shall comply with ASTM C858, except as
         modified herein.
      b. Do not use panel-type vaults unless prior written acceptance is obtained
         from the ENGINEER.
   2. Each member or element shall be marked to indicate location in the structure,
      exterior face, manufacturer, and date of fabrication.

B. Design Criteria:
   1. Design loads shall be in accordance with ASTM C 857, except as modified
      herein.
2. Vehicle and pedestrian loads: Designation A-16, per Table 1 of ASTM C 857. Increase loads for impact and distribute wheel loads based on soil cover over the structure as specified in ASTM C 857.

3. Live Loads on Covers and Roof Slabs:
   a. Vehicle and pedestrian loads as specified. Minimum 1,000 pound concentrated load, located so as to produce maximum stress.
   b. Minimum 300 pounds per square foot loading over entire slab.

4. Seismic Loads: Design shall meet seismic requirements specified in Section 01612.

5. Soil bearing pressure: Maximum 1,500 pounds per square foot net increase on prepared subgrade soils.

6. Groundwater, Flooding, and Buoyant Loads:
   a. Groundwater: Design for maximum site groundwater level taken at the elevation of finished grade around the structure.
   b. Flooding: Design based on 100-year flood elevation of 5 feet.
   c. Buoyancy: For groundwater and flood conditions, provide minimum 1.20 factor of safety against flotation. If the weight of soil surrounding the structure is used to resist flotation, calculations shall consider the buoyant weight of the soil using a unit weight of not more than 30 pounds per cubic foot.

7. Lifting and Handling: Make provisions in the design to accommodate additional stresses or loads that may be imposed during factory pre-casting, transporting, or erecting.

8. Load Combinations: Design structure to sustain loads individually or in combination.

C. Materials:
   1. Concrete:
      a. Minimum specified 28-day compressive strength, f'c: 4,500 pounds per square inch.
      b. Maximum ratio of water to cementitious materials: 0.40.
      c. Air entrainment: 5.5 percent + 1.5 percent.
      d. Cement: Low-alkali.

D. Manufactured Units:
   1. Size: As indicated on the Drawings, and to suit duct banks, conduit, and cable installation requirements identified on the plans:
      a. Minimum Interior Dimensions:
         1) As required to provide a clear working space with minimum horizontal dimensions of not less then 3 feet in any direction.
         2) Not less than the following, unless otherwise indicated on the Drawings:
   2. Details of Construction:
      a. Manhole Floor: Construct as monolith. Where sump is included, slope floor to sump pit.
      b. Minimum Wall and Slab Thickness: 5 inches.
      c. Minimum Concrete Cover Over Reinforcement: 2 inches of clear concrete cover between any face of the concrete and embedded steel reinforcement:
         1) Where cable racks are embedded on interior walls, provide minimum 1 inch clear concrete cover between back face of rack and steel reinforcement.
d. Access: Locate access openings so that they are not directly over cables, equipment, or obstructions.
e. Joints: Include details and sealing compounds as required to provide a watertight installation.

3. Source Quality Control:
   a. Submit concrete mix designs and compressive strength test reports for record.
   b. Manufacturer shall provide inspection during construction of precast concrete structures in accordance with ASTM C1037. Confirm that products conform to the requirements of ASTM C858 and this Section. Submit inspector’s reports.

E. Manufacturers:
   1. One of the Following or equal:
      a. Oldcastle Precast (including Utility Vault Company, Amcor, W.R. White, and Brooks Products.)

2.03 ACCESSORIES

A. Pulling Eyes/Irons:
   1. Design Criteria:
      a. Designed and installed to withstand twice the load expected to be applied to the pulling iron.
      b. Secured to wall reinforcement. Isolate dissimilar metals using dielectric materials.

B. Cable Racks:
   1. Preformed channels.
   2. Materials: Non-corrosive spaced to support each conductor at 2-foot intervals.

C. Manhole Covers:
   1. Cast iron; frame and inner pan for traffic loading and for electrical installations; inner pan with caulking joint; radial block tread, lifting ring, and machined to fit; word, “ELECTRICAL”, engraved on top side; 30-inch clear opening.
   2. Design criteria.
   3. Manufacturers: One of the following or equal:
      a. Alhambra Foundry.

D. Conduit/Duct Bank Penetration Sealing System:
   1. See Drawings for details of penetrations at pull boxes and electrical manholes.

E. Grounding Conductor: Furnish a [3/0] bare copper grounding electrode conductor in the floor slab of each manhole or pull box. Allow an 8 foot exposed length of this conductor for ground connection to duct bank ground conductor.

PART 3 EXECUTION

3.01 INSTALLATION

A. Furnish and install pull boxes and manholes as indicated on the Drawings, in accordance with ASTM C891, and as specified. Install additional pull boxes and manholes as required to meet cable manufacturer’s pulling tension requirements.
B. Set boxes and electrical manholes plumb and true to site construction lines.

C. Place base sections over minimum 12 inches of compacted aggregate base course. Level subgrade so that base with be plumb and ductbanks and conduits will be on proper grade and alignment. Wedging or blocking of base sections will for leveling will not be permitted.

D. Clean and prime joints between precast sections. Install sealing compound between adjacent sections and provide watertight joints.

E. Set vault wall sections plumb, using sections of required heights to bring top of manhole to required elevation.

F. Set covers and hatches at elevations indicated on the Drawings. Securely attach frames to top of precast structure, or on grade adjustment rings:
   1. Where no paving surrounds structure, set top of pull box or manhole cover minimum 6 inches above surrounding grades.
   2. In paved areas, set pull box or manhole cover flush with paving.

G. Backfill structures in accordance with the provisions of ASTM C 891 (except that jetting is not permitted).

3.02 REPAIR/RESTORATION

A. Repair cracks and blemishes in concrete by methods acceptable to the ENGINEER. Repair to damaged or broken concrete will not be permitted.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.04 ADJUSTING

A. Refer to Section 01756.

3.05 CLEANING

A. Before installation of cables in any duct bank/manhole systems, remove all concrete spoilage, forms, debris, etc.

3.06 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Switches.
   2. Receptacles.
   3. Plates.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. Underwriters Laboratories Inc. (UL):
   1. 20 - General use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General color requirement for wiring devices.
   2. ICS 5 - Control circuits and pilot devices.
   3. OS1 - Device box, covers, and box supports.
   4. WD6 - Wiring devices dimensional requirements.

D. Federal Specification:
   1. W-C 596.
   2. W-S 896.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions:
   1. GFCI: Ground Fault Circuit Interrupter.
   2. P-S: Pass and Seymour.
   3. CWD: Cooper Wiring Devices.
   4. T&B: Thomas and Betts.
1.04 SYSTEM DESCRIPTION
A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330 and 16050.
B. Product Data:
   1. Catalog cut sheets.
C. Shop Drawings:
   1. Engraving Schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE
A. Refer to Section 16050.
B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
A. Refer to Section 16050.

1.09 WARRANTY
A. Refer to Section 16050.

1.10 SYSTEM START-UP
A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Switches:
   1. General Purpose Toggle Switches, one of the following or equal:
      a. Part Numbers are for Brown Switches:
         | 1-pole | 2-pole | 3-way | 4-way |
         |        |        |       |       |
         | Hubbell| HBL 1221| HBL 1222| HBL 1223| HBL 1224|
         | Leviton| 1221-2  | 1222-2  | 1223-2  | 1224-2  |
         | CWD    | 4901    | 4902    | 4903    | 4904    |
2. Switches for NEMA 4 and NEMA 4X Locations, one of the following or equal:

<table>
<thead>
<tr>
<th></th>
<th>1-pole</th>
<th>2-pole</th>
<th>3-way</th>
<th>4-way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>HBL 1281</td>
<td>HBL 1282</td>
<td>HBL 1283</td>
<td>HBL 1284</td>
</tr>
<tr>
<td>Cooper Wiring Devices</td>
<td>2291</td>
<td>2292</td>
<td>2293</td>
<td>2294</td>
</tr>
</tbody>
</table>

3. Switches for Photocells, one of the following or equal:

<table>
<thead>
<tr>
<th></th>
<th>Single-pole, double-throw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>HBL 1385</td>
</tr>
<tr>
<td>CWD</td>
<td>2226</td>
</tr>
</tbody>
</table>

B. Receptacles:

1. General Purpose Receptacles, one of the following or equal:

<table>
<thead>
<tr>
<th></th>
<th>Single</th>
<th>Duplex</th>
<th>GFCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>HBL5361</td>
<td>HBL5362</td>
<td>GF5362A</td>
</tr>
<tr>
<td>Leviton</td>
<td>5361</td>
<td>5362</td>
<td>6899</td>
</tr>
<tr>
<td>CWD</td>
<td>5361B</td>
<td>5362B</td>
<td>HGF20B</td>
</tr>
</tbody>
</table>

C. Plates one of the following or equal:

1. General Location, one of the following or equal:

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Duplex</th>
<th>GFCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-S</td>
<td>SS1-N</td>
<td>SS26</td>
<td>SS8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WPH26</td>
</tr>
</tbody>
</table>

2. Wet or Corrosive areas, one of the following or equal:

<table>
<thead>
<tr>
<th></th>
<th>Indoor</th>
<th>Outdoor</th>
<th>Duplex</th>
<th>GFCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>1750</td>
<td>CCT</td>
<td>CKMD</td>
<td></td>
</tr>
<tr>
<td>T&amp;B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-S</td>
<td>CAI-GL</td>
<td></td>
<td>CA8-GH</td>
<td>3780-SC</td>
</tr>
</tbody>
</table>

2.02 MANUFACTURED UNITS

A. Switches:

1. General:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>f.</td>
<td>Totally enclosed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g.</td>
<td>Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h.</td>
<td>Color:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>1) Ivory in finished areas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j.</td>
<td>2) Brown in all other areas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. General purpose switches:
a. Toggle type.

3. Corrosive and wet areas requiring NEMA 4 or NEMA 4X enclosures:
   a. Toggle switch
   b. Back and side wired.

4. Switches for use with photocell:
   a. Maintained contact.
   b. Two circuit.
   c. Three position:
      1) Center off.

B. Receptacles:
   1. General purpose receptacles:
      a. Single or duplex as indicated on the Drawings.
      b. 125 VAC.
      c. Twenty ampere or as indicated on the Drawings.
      d. NEMA 5-20R configuration for 20 ampere receptacles.
      e. Other NEMA configurations as indicated on the Drawings.
      f. Specification grade.
      g. Back wired.
      h. One-piece mounting strap.
      i. Color:
         1) Ivory in finished areas.
         2) Brown in all other areas.
         3) Orange when powered by a UPS.

   2. Ground Fault Interrupter Receptacles (GFI):
      a. 125 VAC.
      b. 20 ampere.
      c. Trip level 4-6 milliampere.
      d. Individual and feed through protection.
      e. UL 943 and UL 498 listed.
      f. NEMA 5-20R configuration.

C. Plates:
   1. General location:
      a. Type 302 or 304 stainless steel.
      b. Brushed satin finish.
      c. Minimum thickness: 0.032 inches.
      d. Rectangular or square shape.
      e. Engraving:
         1) Engrave each plate with the following information:
            a) Area served.
            b) Circuit number.
         2) Treat engraving to improve visibility and, except for stainless steel plates, to prevent corrosion.
         3) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
      f. Coordinate the number of gangs, number and type of openings with the specific location.

   2. Outdoor and wet areas requiring NEMA 4 or NEMA 4X enclosures:
      a. General:
         1) UL listed for wet locations.
         2) Gasketed.
3) Die Cast Metal:
   a) Match material to box material.
   b. Switches:
      1) Lever-operated.
3. Corrosive Areas:
   a. Neoprene.
   b. Gasketed.
   c. Weatherproof.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Mounting heights:
   1. Process and production areas:
      a. Switches and receptacles 42 inches from finished floor to center of plate.

C. Receptacles:
   1. Provide GFCI receptacles in the following locations:
      a. Outdoors.
      b. Other locations as indicated on the Drawings.
   2. Mount non-weatherproof receptacles vertically:
      a. Ground slot down.
   3. Mount weatherproof receptacles horizontally:
      a. Neutral slot up.
   4. Three phase receptacles shall be consistent with respect to phase connection
      at the receptacle terminals. Correct errors in phasing at the source and not the
      receptacle.

D. Ensure All Plates make a Firm Seal with Wall for Recessed Mounted Devices:
   1. Outside edges of plates parallel with building lines.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Demonstrate the following to the ENGINEER and OWNER:
   1. Switching is per the Drawings.
   2. All circuits conform to the panel schedules.
   3. All ground fault receptacles operate at levels below or equal to OSHA
      maximum allowable fault levels.

3.04 PROTECTION

A. Refer to Section 16050.
END OF SECTION
SECTION 16150
WIRE CONNECTIONS

PART 1  GENERAL

1.01  SUMMARY

A. Section includes requirements for:
   1. Wire connecting devices.
   2. Terminations.

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

1.02  REFERENCES

A. Refer to Section 16050.

1.03  DEFINITIONS

A. Refer to Section 16050.

1.04  SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05  SUBMITTALS

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

B. Product Data:
   1. Catalog cut sheets.
   2. Installation instructions.

1.06  QUALITY ASSURANCE

A. Refer to Section 16050.

B. All materials shall be UL listed.

1.07  DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.
1.08 PROJECT OR SITE CONDITIONS
   A. Refer to Section 16050.

1.09 WARRANTY
   A. Refer to Section 16050.

1.10 SYSTEM START UP
   A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Manufacturers for each type of technology are listed with the units listed in
      Section 2.05 below.

2.02 EQUIPMENT
   A. Control Connections:
      1. Use insulated ring type wire terminators for connections to all screw terminals:
         a. With chamfered/funneled terminal barrel entry.
         b. Deep internal serrations.
         c. Long barrel design to reduce electrical resistance and increased insulator-
            barrel surface area to ensure that the insulator remains in contact with the
            barrel.
         d. Electroplated-Tin copper conductor.
         e. Manufacturer: One of the following or equal:
            1) Thomas and Betts, Stakon.
      2. For process equipment connections work from manufacturer's drawings.
   
   B. Joints, Splices, Taps, and Connections:
      1. For 600-volt conductors use solderless connectors.
      2. Use Only Plated Copper Alloy Connectors or Lugs:
         a. Aluminum connectors or lugs are not acceptable for copper conductors.
      3. For wire Number 10 AWG and smaller use compression splice caps, with
         insulating caps:
         a. Manufacturer: One of the following or equal:
            1) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps.
      4. For wire Number 8 AWG and larger, use heavy duty copper compression
         connectors:
         a. Manufacturer: One of the following or equal:
            1) Burndy.
            2) Thomas and Betts.
      5. Where waterproof splices are required:
         a. Suitable for indoor, outdoors, weather exposed, direct buried, or
            submersed applications.
         b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
         c. For use with shielded or unshielded plastic- and rubber-jacketed, signal,
            control, and power cables rated up to 1 kV.
d. Two-part mold body with tongue and groove seams and built in spacer webbing.
e. Manufacturer: One of the following or equal:
   1) 3M - Scotchcast 72-N.

C. Insulating Tape:
   1. General Purpose Insulating Tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
      c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
      d. Flame retardant, hot- and cold- weather resistant, UV resistant.
      e. For use as a primary insulation for wire cable splices up to 600 VAC.
      f. Meeting and Complying with:
         1) ASTM D-3005 Type I.
         2) UL 510.
         3) CSA C22.2.
      g. Manufacturer: One of the following or equal:
         1) 3M - Scotch Number Super 33+.
   2. General-Purpose Color-Coding Tape:
      a. Minimum 7-mil vinyl tape.
      b. Suitable for application on PVC and polyethylene jacketed cables.
      c. For use indoors and outdoors in weather protected enclosures.
      d. Available with the Following Colors:
         1) Red.
         2) Yellow.
         3) Blue.
         4) Brown.
         5) Gray.
         6) White.
         7) Green.
         8) Orange.
         9) Violet.
      e. For use as phase identification, marking, insulating, and harnessing.
      f. Meeting and Complying with:
         1) UL 510.
         2) CSA C22.2.
      g. Manufacturer: One of the following or equal:
         1) 3M - Scotch Number 35.

PART 3 EXECUTION

3.01 INSTALLATION

   A. Refer to Section 16050.

   B. Load connections:
      1. Connect loads to the circuits as indicated. Color-code all branch circuits per Section 16123.
C. Zero to 600-Volt Systems:
   1. Make all connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number all power and control wires before termination.

D. Motor connections (600 Volts and Below):
   1. Terminate wires with compression type ring lugs at motors.
   2. Connection at both the motor leads and the machine wires are to have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturer: one of the following or equal:
      a. Raychem MCK.

3.02 FIELD QUALITY CONTROL
   A. Refer to Section 16050.

3.03 PROTECTION
   A. Refer to Section 16050.

END OF SECTION
SECTION 16210
UTILITY COORDINATION

PART 1 GENERAL

1.01 SUMMARY

  A. Section Includes Requirements for:
     1. Coordination with the Utility companies to provide service.
     2. CONTRACTOR’s responsibilities for connecting to utilities and providing utility service to the facilities.
     3. Descriptions of utility services required.

  B. Related Sections:
     1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its subcontractors to review all sections to ensure a complete and coordinated project.
     2. Section 01210 - Allowances
     3. Section 16050 – General Requirements for Electrical Work

1.02 REFERENCES

  A. Refer to Section 16050.

1.03 DEFINITIONS

  A. Refer to Section 16050.

  B. Utility Contacts:
     1. Electric Utility:
        a. Name: Paul Rodriguez
        b. Utility: Turlock Irrigation District (TID)
        c. Phone number: (209) 883-8438

1.04 SYSTEM DESCRIPTION

  A. Electrical Service:
     1. Provide all work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
        a. All work and materials not provided by the Electric Utility.
        b. All permits and fees required by the Electric Utility.
     2. Provide electrical ducts, raceways, conductors and connections indicated on the Drawings, and all other work and materials required for a complete electrical service, including but not limited to the following:
        a. Electrical service conduits and conductors from the point of Electric Utility connection to the service entrance equipment.
b. Metering conduits from the instrument transformers to the meter.

B. General:
1. Coordinate and obtain inspections and final installation approval from serving utilities and other authorities having jurisdiction.

1.05 SUBMITTALS

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

B. Certification:
1. Submit certification that the intended installation has been coordinated with the Utility companies.
2. Certification shall include a narrative description of the Utility’s requirements and points of connection and names and telephone numbers for contacts at the Utilities.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Materials and equipment used in performance of electrical work shall be listed or labeled by Underwriter’s Laboratories or other equivalent recognized, and independent testing laboratory, for the class of serves intended.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.08 SCHEDULING

A. General:
1. Before start of site work, make arrangements for temporary telephone and electrical service as required.

B. Electrical systems:
1. Before bidding, the Electrical Contractor shall contact the Utilities to determine the work and materials that will be required from the CONTRACTOR, and all fees and permits that will be required, so that all utility systems furnished by the CONTRACTOR will be included in the bid.
2. Coordinate work with ENGINEER to minimize downtime of existing operating equipment and electrical distribution systems and to preclude unsafe operation:
   a. Notify OWNER 10 days before power interruptions.
   b. Coordinate downtime with OWNER and local Electric Utility.
3. Before commencing work, coordinate electric service entrance requirements with local Electric Utility to assure that the installation will be complete in accordance with these Specifications:
   a. Ensure power transformer size, electrical characteristics, and location are consistent with the design and service voltage provided by the Electric Utility coordinated with other trades.
b. Arrange for Utility Revenue meter.
c. Furnish and coordinate installation of metering C.T.'s and P.T.'s furnished by the Electric Utility.
d. Pay any charges required by the Electric Utility for connection and turn-on.

C. Before commencing site work, coordinate underground conduit installations with other work to eliminate conflicts and avoid interferences with other underground systems.

1.09 WARRANTY

A. Refer to Section 16050.

1.10 SYSTEM START-UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish materials in accordance with the applicable requirements of the utilities and these Specifications.

2.02 EQUIPMENT

A. Furnish equipment in accordance with the applicable requirements of the Utilities and these Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 CLEANING

A. Refer to Section 16050.

3.04 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16222
LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes Requirements for:
   1. Low voltage motors up to 500 horsepower:
      a. Furnished separately.
      b. Part of driven equipment specified in other Sections.
      c. Other electric motors required for a complete installation.

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

1.02  REFERENCES

A. Refer to Section 16050.

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

C. American Petroleum Institute (API):

D. Institute of Electrical and Electronic Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
   4. 303 - Recommended Practice for Auxiliary Devices for Motors in Class 1, Groups A, B, C, and D, Division 2 Locations.
   5. 841 - Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500hp.

E. National Electrical Manufacturers' Association (NEMA):
   1. MG-1 - Motors and Generators.

1.03  DEFINITIONS

A. Refer to Section 16050.
1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories in conformance with this Section, and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

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

B. Submit Completed Motor Data Sheets for Each Motor Supplied:
   1. Refer to data sheet in part 3.12 of this Section.

C. Product Data:
   1. Descriptive bulletins.
   2. Machine tag and loop number as identified in the P&IDs, and Specification Section number of the driven machine.
   3. Electrical Data:
      a. Voltage and Phase.
      b. Horsepower:
         1) Nameplate Horsepower.
      c. Service Factor:
         1) Nameplate Service Factor.
         2) Service Factor available at project altitude.
      d. At Rated Horsepower and Voltage:
         1) Full load amps.
         2) RPM.
      e. Efficiency at 1/2 and 3/4 and full load.
      f. Power factor at 1/2 and 3/4 and full load.
      g. Torque, current, and power factor vs. speed curves at 80 percent and 100 percent rated voltage.
      h. Locked rotor withstand time, with the motor at ambient temperature and at its maximum rated operating temperature, at 70 percent, 80 percent, 90 percent, and 100 percent of rated voltage.
      i. NEMA design.
      j. Description of insulation system.
      k. Winding insulation class and rated ambient temperature.
   4. Accessories Data:
      a. Power Factor Correction Capacitors:
         1) Size in KVAR, for all motors not connected to variable frequency drives.
      b. Motor Winding Heaters:
         1) Voltage.
         2) Watts.
      c. Winding Temperature Detectors:
         1) Type.
         2) Rating.
      d. Moisture Detectors.
   5. Mechanical Data:
      a. Bearing design and bearing life calculations.

D. Shop Drawings:
1. Motor weight.
2. Frame size.
3. Conduit box location.
4. Outline drawings with dimensions.
5. Seismic installations details for site conditions defined in Section 01612.

E. Test Reports:
   1. Factory test reports with test reference standard identified.

F. Certification:
   1. When motors are driven by variable speed drive systems, submit certification that selected motor:
      a. Is capable of satisfactory performance under the intended load.
      b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
      c. Is matched to the type of variable frequency drive specified.

G. Calculations:
   1. Where site conditions specified in Section 16050 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. All motors shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

B. Motors 200HP and Larger:
   1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 WARRANTY

A. Refer to Section 16050.

1.10 SYSTEM STARTUP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following:
   1. US Motors.
   2. General Electric.
3. Reliance.
4. Toshiba.
5. Baldor.

2.02 EQUIPMENT

A. 3 Phase Induction Motors - General:

1. Voltage:
   a. All motors 1/2 hp and larger shall be 460V, 3 phase unless otherwise indicated on the Drawings.
   b. Dual voltage motors rated 230/460V, 3 phase are acceptable provided all leads are brought to the conduit box.

2. Motors driving identical machines shall be identical.

3. All motors 1 hp and larger shall be “Premium Efficiency” motors as defined in NEMA MG-1.

4. Horsepower as Indicated on the Drawings:
   a. Horsepower ratings shown on the drawings are based on Vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.

5. Service Factor:
   a. Provide motors rated at 1.15 Service Factor.
   b. Provide motors capable of operating continuously at 1.15 Service Factor at project altitude:
      1) Without exceeding Class B temperature rise limits where motors are provided with Class F insulation.
      2) Without exceeding Class F temperature rise limits where motors are provided with Class H insulation.

6. Torque:
   a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
   b. When Started Using Reduced Voltage Starters:
      1) Provide motors that develop sufficient torque for acceleration to full speed.
   c. NEMA Design B except where driven load characteristics require other than normal starting torque:
      1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.

7. Enclosures:
   a. As indicated in the individual equipment specifications or as specified in this Section.
   b. Totally Enclosed Fan Cooled:
      1) Cast iron conduit box.
      2) Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger.
   c. Lifting Devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.

8. Manufactured with cast iron frames in accordance with NEMA MG-1.

9. Nameplates:
   a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
      1) NEMA Standard motor data.
2) Bearing description and lubrication instructions.

10. Hardware:
   a. Type 316 stainless steel.

11. Conduit Boxes:
   a. Cast iron or stamped steel.
   b. Split from top to bottom.
   c. Provide Gaskets at the Following Interfaces:
      1) Frames and conduit boxes.
      2) Conduit boxes and box covers.
   d. Rotatable through 360 degrees in 90 degree increments.
   e. Exceeding the dimensions defined in NEMA MG-1.
   f. Provide grounding lugs inside conduit boxes for motor frame grounding.

12. Motor Bearings:
   a. Antifriction.
   b. Regreasable and initially filled with grease.
   c. Bearings and lubrication suitable for ambient temperature and
      temperature rise.
   d. Suitable for intended application and have ABMA L-10 rating life of
      60,000 hours or more.
   e. Fit bearings with easily accessible grease supply, flush, drain, and relief
      fittings using extension tubes where necessary.
   f. Where specified in the equipment specifications, provide split-sleeve type
      hydrodynamic radial bearings. Provide a bearing isolator to protect
      bearings from contaminants.

13. Insulation Systems:
   a. Motors Installed in Ambient Temperatures 40 degrees Celsius or Less:
      1) Provide Class F insulation.
      2) Design temperature rise consistent with Class B insulation.
      3) Rated to operate at an ambient temperature of 40 degrees Celsius
         and at the altitude where the motor will be installed.
   b. Motors Installed in Ambient Temperatures between 40 degrees Celsius
      and 65 degrees Celsius:
      1) Provide Class H insulation.
      2) Design temperature rise consistent with Class F insulation.
      3) Rated to operate at an ambient temperature of 65 degrees Celsius
         and at the altitude where the motors will be installed.

14. Motor Leads:
   a. Insulated leads with non-wicking, non-hydroscopic material. Class F
      insulation.

15. Noise:
   a. Maximum operating noise level of 85dB measured as per IEEE 85.

B. Vertical Motors:
1. Enclosures:
   a. Weather Protected Type II (WPII) where installed outdoors.
   b. Weather Protected Type I (WPI) where installed indoors.

2. Thrust bearings:
   a. Selected for combined rotor and driven equipment loads.
   b. Coordinate with driven equipment supplier for maximum vertical thrust of
      driven equipment.

3. Anti-reverse ratchet.
C. Variable Frequency Drive Motors:
   1. Compatible with the variable frequency drives specified.
   2. Inverter duty rated and labeled.
   3. Meet the requirements of NEMA MG-1 Part 31.
   4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
   5. Capable of running continuously at 1/10th of full speed, with no harmful effects
      or overheating.
   6. Service factor of 1.0 when driven by VFD.
   7. Shaft grounding ring:
      a. Provide a shaft grounding ring for each VFD driven motor.
      b. Aluminum frame and internal components.
      c. Conductive microfiber brushes.
      d. Maintenance free design.
      e. Aegis Bearing Protection ring as manufactured by Electro Static
         Technology or equal.

D. Single Phase Motors:
   1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise
      specified or as indicated on the Drawings.
   2. Totally enclosed, fan cooled motors manufactured in accordance with NEMA
      MG 1.
   4. 1/2 Horsepower or Less Fan Motors:
      a. Split-phase or shaded pole type when standard for the equipment.
      b. Open type when suitably protected from moisture, dripping water, and lint
         accumulation.
   5. Wound rotor or commutator type single-phase motors only when their specific
      characteristics are necessary for application and their use is acceptable to the
      ENGINEER.
   6. Integral overload protection.

2.03 ACCESSORIES

A. Motor Winding Heaters:
   1. Provide all 3 phase motors with belted or cartridge space heaters mounted
      within the motor enclosure.
   2. Space heater rating shall be 120 volts, single-phase, unless otherwise shown.
   3. Power leads for heaters wired into conduit box.
   4. Installed within motor enclosure adjacent to core iron.

B. Winding Temperature Detectors:
   1. Temperature switches with normally closed contacts as indicated on the
      Drawings.

C. Bearing Temperature Detectors:
   1. Where required by the driven equipment Specification or as indicated on the
      Drawings.

D. Vibration Detectors:
   1. Where required by the driven equipment specification.
   2. In accordance with the driven equipment specification.
2.04 SOURCE QUALITY CONTROL

A. Factory Testing:
   1. Perform Factory Tests in Accordance with:
      a. IEEE 112 for three phase motors.
      b. IEEE 114 for single phase motors.
   2. Furnish copies of test reports.
   3. Include Testing of:
      a. No load current.
      b. Locked rotor current.
      c. Winding resistance.
      d. High potential.
   4. Tests Required on Motors 250 Horsepower and larger:
      a. Manufacturer’s routine test (use polarization index voltage = 5000V for insulation resistance tests).
      b. Efficiency and power factor versus load test performed at rated speed and 50 percent, 75 percent, 90 percent, and 100 percent of rated load. The curves from the motor tests shall be submitted for information.
      c. The maximum allowable residual unbalance in each correction plane (journal) shall be calculated using the following equation:
         \[ U = 4 \frac{W}{N} \]
         where:
         \[ U \] = residual correction plane unbalance, in ounces-inches
         \[ W \] = static correction plane journal loading, in pounds
         \[ N \] = maximum specified operating speed, in revolutions per minute

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Install motors in accordance with manufacturer’s instructions.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
   1. Windings energized to 1,000 volts D.C. for 1 minute.
   2. Resistance measured at the end of the test, recorded, and submitted to the ENGINEER for review.
   3. Inform the ENGINEER of any unusual or unacceptable test results.
   4. This test is in addition to the acceptance tests in Section 16950.

3.03 PROTECTION

A. Refer to Section 16050.
3.04 SCHEDULES

A. Motor Data Sheet
## MOTOR DATA SHEET

### MOTOR NUMBER ___________________ MOTOR / EQUIPMENT NAME _______________________

### SPECIFICATION NUMBER OF DRIVEN MACHINE ____________________________________________

### MOTOR NAMEPLATE DATA

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>MODEL/SERIES</th>
<th>MODEL NO.</th>
</tr>
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### MOTOR NAMEPLATE DATA

<table>
<thead>
<tr>
<th>FRAME</th>
<th>ENCLOSURE</th>
<th>NEMA DESIGN</th>
</tr>
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</table>

### FRAME ______________ ENCLOSURE ______________ NEMA DESIGN ______________

<table>
<thead>
<tr>
<th>HP</th>
<th>SERVICE FACTOR</th>
<th>RPM</th>
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<table>
<thead>
<tr>
<th>INSULATION CLASS</th>
<th>VOLTS</th>
<th>FULL LOAD AMPS</th>
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<table>
<thead>
<tr>
<th>AMBIENT TEMP</th>
<th>PHASE</th>
<th>NO LOAD AMPS</th>
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<table>
<thead>
<tr>
<th>DESIGN TEMP RISE</th>
<th>HERTZ</th>
<th>LOCK ROTOR AMPS</th>
<th>INRUSH CODE LETTER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

### DESIGN TEMP RISE ___________ HERTZ _______________________ LOCK ROTOR AMPS ______________ INRUSH CODE LETTER ______________

### 100 PERCENT LOAD  75 PERCENT LOAD  50 PERCENT LOAD

<table>
<thead>
<tr>
<th>GUARANTEED MINIMUM EFFICIENCIES:</th>
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<table>
<thead>
<tr>
<th>GUARANTEED MINIMUM POWER FACTOR:</th>
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</table>

### MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: ______________ KVAR

### ACCESSORIES

<table>
<thead>
<tr>
<th>MOTOR WINDING HEATER</th>
<th>VOLTS</th>
<th>WATTS</th>
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</table>

### WINDING THERMAL PROTECTION

### WINDING TEMP SWITCHES (YES/NO) ______________

<table>
<thead>
<tr>
<th>RTD: TYPE</th>
<th>QUANTITY PER PHASE</th>
<th># OF WIRES</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
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<th>NOMINAL TEMP</th>
<th>COEFFICIENT</th>
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<tbody>
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</table>

### RECOMMENDED ALARM DEGREES CELSIUS RECOMMENDED TRIP DEGREES CELSIUS

### SPECIAL APPLICATIONS

<table>
<thead>
<tr>
<th>INVERTER DUTY* (YES/NO)</th>
<th>PART WINDING (YES/NO)</th>
<th>WYE - DELTA (YES/NO)</th>
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<table>
<thead>
<tr>
<th>2 SPEED, 1 WINDING (YES/NO)</th>
<th>2 SPEED, 2 WINDING (YES/NO)</th>
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</thead>
<tbody>
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</table>

### AREA CLASSIFICATION:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DIVISION</th>
<th>GROUP</th>
<th>TEMP CODE</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

### (YES/NO)

### 2 SPEED, 1 WINDING (YES/NO) ______________ 2 SPEED, 2 WINDING (YES/NO) ______________

### AREA CLASSIFICATION:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DIVISION</th>
<th>GROUP</th>
<th>TEMP CODE</th>
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### * Conforms to NEMA MG-1 Part 31.

END OF SECTION
SECTION 16264

VARIABLE FREQUENCY DRIVES 60-500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Clean power 18 pulse variable frequency drives, VFD, 60 to 500 horsepower for control of standard NEMA Design B squirrel cage induction motors.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 volts maximum).
   2. MGI, Part 31 - Motors with higher peak voltage capability.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

D. Underwriters’ Laboratories (UL):
   1. 50 Standards for Enclosures for Electrical Equipment.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions:
   1. Point of Common Coupling, (PCC): the point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the input terminals to the VFD.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Each variable frequency drive system shall consists of all components required to meet the performance, protection, safety, testing and certification criteria of this specification.
a. CONTRACTOR shall coordinate the VFD sizing with the actual motors provided for the Project. The VFD sizing shall adhere to all requirements of these specifications.

2. The VFD System:
   a. Is a fully integrated package.
   b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.

3. Any modifications to a standard product necessary to meet this specification shall be made only by the VFD manufacturer.

4. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.

5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
   a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.

6. VFDs shall include an integral Reduced Voltage Solid State bypass starter, Refer to Section 16422 for additional requirements.

7. Refer to Section 17710 for control panel, enclosures, and control panel components, requirements

B. Performance:

1. Operating Envelope:
   a. Speed and Torque Requirements:
      1) Provide a variable torque or constant torque VFD as required by the driven load.
      2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 Hertz) speed range.
   b. Current Requirements:
      1) Provide 100 percent of rated output current on a continuous basis.
      2) Variable Torque VFD:
         a) Minimum 110 percent current overload for 1 minute.
      3) Constant Torque VFD:
         a) Minimum 150 percent current overload for 1 minute.

2. Harmonics:
   a. The VFD shall comply with the latest edition of IEEE 519 for total harmonic and current distortion calculations and measurements. The VFD shall meet the following distortion limits:
      1) Voltage Harmonics: Individual or simultaneous operation of the VFD(s) shall not add more than 3 percent total harmonic voltage distortion while operating from the utility source or more than 5 percent total harmonic voltage distortion while operating from standby generation at the PCC.
      2) Current Harmonics: The maximum allowable total harmonic current distortion limit for each VFD shall not exceed 5 percent as measured at the PCC.

3. Efficiency:
   a. VFD system minimum efficiency shall be 96 percent at rated output. VFD system efficiency shall be calculated as follows:
1) Power (Load) is the total 3-phase power measured at the output terminals of the drive system, including VFD, output filters or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, phase shifting transformer, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.

4. Total Power Factor:
   a. Minimum of 0.96 lagging across the entire speed range.
   b. At no speed shall the VFD have a leading power factor.

5. Frequency Accuracy:
   a. Minimum of within 0.01 percent.

6. Speed Regulation:
   a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish Submittals in Accordance with Sections 01330 and 16050:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product Data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Weight.
   5. Nameplate Schedule.
   6. Bill of material.
   7. Ratings:
      a. Voltage.
      b. Phase.
      c. Current.
      d. Interrupting rating.
      e. Momentary current rating.
   8. Catalog Cut sheets for major components.
   9. Design Data:
      a. Efficiency and power factor values.
      b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude.
      c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.

\[
Efficiency\% = \frac{Power\ (Load)}{Power\ (Supply)} \times 100
\]
10. List of recommended spare parts.

C. Shop Drawings:
   1. Complete Plan and Elevation Drawings Showing:
      a. All dimensions.
      b. Panel, sub-panel and component layout indexed to the Bill of Material.
      c. Conduit connections.
      d. Required clearance around equipment.
   2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
   3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
      a. Wiring diagrams shall include terminal number and wire numbers.
   4. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
      a. Device electrical ratings shall be clearly indicated on the Drawings.

D. Installation Instructions:
   1. The written instructions must detail the complete installation of the VFD including moving, and setting into place.
   2. Provide anchorage instructions and requirements for the VFD based on the seismic conditions of the site as specified in Section 01612:
      a. Stamped by a Professional Engineer registered in the state where the project is being constructed.

E. Calculations:
   1. Harmonic Study:
      a. A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 20 shall be used. All VFDs shall be assumed to be operating at maximum speed and maximum load. The short circuit current (ISC) utilized for the harmonic analysis calculations is defined as:
         1) ISC = 20 * (Sum Total Full Load Amps of all VFDs).
   2. Detailed calculations or details of the actual physical testing performed on the VFD to prove the VFD is suitable for the seismic conditions at the project site as specified in Section 01612.

F. Test Reports.

G. Record Documents:
   1. Certified record documents of all equipment with information listed above.

H. Manufacturer’s Field Reports:
   1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer’s requirements.
   2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

I. Operation and Maintenance Manuals:
   1. Spare parts list with supplier names and part numbers.
   2. Start-up and commissioning instructions and data.
3. Operating Manuals:
   a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this contract.

4. Operating Instructions:
   a. The written descriptions shall detail the operational functions of all controls on the front panel.

5. Maintenance Manual:
   a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
   b. Manuals shall Include but are Not Limited to the Following:
      1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
      2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.
      3) All Schematic Wiring and External Diagrams:
         a) Furnish drawings in a fully legible reduced 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Qualifications:
   1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
   2. VFD Systems shall be UL listed and labeled.
   3. Variable Frequency Drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

B. Ship VFDs to the job site on a dedicated air ride vehicle that will allow the CONTRACTOR to utilize on site off loading equipment:
   1. VFDs shall be delivered to the site pre-assembled and wired.
   2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 SEQUENCING

A. Submit equipment for review.
B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit Certified Test Results for ENGINEER’s review.

C. Conduct Factory Acceptance Test. The factory acceptance test shall be witnessed by OWNER and/or OWNER’s representative at the OWNER’s discretion.

D. Ship equipment to project site after successful completion of Factory Acceptance Test.

E. Install equipment in the field.

F. Conduct field acceptance tests including harmonic testing and submit results for ENGINEER’s review.

G. Submit manufacturer’s certification that all equipment has been properly installed and is fully functional for ENGINEER’s review.

H. Conduct OWNER's Training Sessions.

I. Formally energize, start-up and commission equipment.

1.10 SCHEDULING

A. Refer to Section 16050.

1.11 WARRANTY

A. Refer to Section 16050.

B. Extended Warranty:
   1. Provide an additional 3 years manufacturers warranty for all equipment provided under this Section.

1.12 SYSTEM START UP

A. Refer to Section 16050.

B. The VFD manufacturer shall be responsible for start up of the VFDs in the presence of the equipment suppliers, CONTRACTOR, ENGINEER and OWNER.

1.13 COMMISSIONING

A. After start-up and training has been completed, the VFDs shall be commissioned by the VFD manufacturer:
   1. The VFDs shall operate the driven load without failure under normal operating conditions for a period of 30 days.
   2. Any failures shall be repaired by the VFD manufacturer. Following repair, the commissioning period shall be restarted.
   3. Commissioning shall only be complete once an uninterrupted 30 period has been completed.
1.14 MAINTENANCE

A. Maintenance Service: manufacturer shall describe the field service system available to support the proposed variable frequency drive system. As a minimum describe:
   1. Type of technical support available (e.g., system engineering and technician).
   2. Location of field service personnel.
   3. Field service daily rates in dollars per hour and dollars per day.
   4. Guaranteed response times to service requests.

B. Spare Parts: As a minimum, provide the following spare parts:
   1. One set of all power and control fuses for each VFD.
   2. One complete main control keypad for each type and rated size of VFD.
   3. One spare fan for each VFD unit.
   4. Two sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
   5. Any special dedicated tools for emergency service and troubleshooting.
   6. One set of power electronics for each type and rated size of VFD.
   7. Supply all hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following or Equal:
   1. Eaton-Cutler Hammer.
   3. Toshiba.
   4. Siemens-Robicon.

2.02 EQUIPMENT

A. General:
   1. Sinusoidal Pulse Width Modulated, (PWM), Type Drive:
      a. Phase shifting transformer.
      b. Direct current link with capacitors.
      c. Minimum 18-pulse rectifier section consisting of 3 three-phase bridge rectifiers.
      d. Insulated gate bipolar transistor, (IGBT), inverter section.
      e. Microprocessor based controls.
      f. Load reactors.
      g. Input and output isolation contactors.

B. Ratings:
   1. Voltage:
      a. Input voltage: 480 Volts plus or minus 10 percent, 3-phase 60 hertz.

C. Operational Features:
   1. Protective Features:
      a. Include the Following Protective Features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
3) Instantaneous overvoltage.
4) Undervoltage.
5) Power unit overtemperature.
6) Phase loss.
7) VFD output short circuit.
8) VFD output ground fault.
9) Blown fuse.

2. Control Mode:
   a. The VFD shall operate in a either a constant volts/hertz or sensorless vector mode. The control mode selectable using the programming keypad.

3. Frequency Control:
   a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
   b. Programmable minimum frequency.
   c. Programmable maximum frequency.

4. Acceleration/Deceleration:
   a. Separately adjustable acceleration and deceleration rates.
   b. Each rate shall be adjustable from 0.01 to 3,600 seconds.

5. Spinning Load:
   a. Capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.

6. Programmable Loss of Signal:
   a. Upon loss of reference speed signal the VFD shall be programmable to either: stop, maintain current speed, default to preselected speed.

7. Power Interrupt Ride-Through:
   a. Capable of continuous operation in the event of a power loss of 5 cycles or less.

8. Input/Output:
   a. Analog Inputs:
      1) Minimum of 2 programmable analog inputs configurable as either 0-10 volts or 4-20 mA:
         a) One analog input shall be directly proportional to speed.
   b. Analog Outputs:
      1) Minimum of 2 programmable 4-20 mA isolated analog outputs:
         a) One analog output shall be directly proportional to speed.
   c. Discrete Inputs:
      1) Minimum of seven programmable discrete inputs.
   d. Discrete Outputs:
      1) Minimum of three programmable discrete, form C relay outputs.
   e. Additional Inputs/Outputs:
      1) Emergency Stop input.
      2) Potentiometer 3-wire input.

9. Communications:
   a. Provide each VFD with a communications interface module.
   b. RS-485 Modbus RTU port.
   c. Provide each VFD with an end-of-line termination resistor for the network specified above.

10. Automatic Control:
    a. PID Capability Utilizing an Internal or External Setpoint.
       1) Selectable setpoint source.

11. Diagnostics:
    a. Minimum of four fault conditions in memory on a first in - first out basis.
b. Operating frequency, drive status and power mode shall also be stored at the time of the fault.
c. Fault memory shall be maintained in the event of a power outage.
d. The fault memory shall be accessible via RS-232, RS-422 or RS-485.

12. Automatic Restart:
   a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
      1) Programmable for up to nine automatic restart attempts with an adjustable time delay between restart attempts.

2.03 COMPONENTS

A. Enclosure:
   1. NEMA 1 enclosure.
   2. Provide cooling devices required to maintain the VFD within the Manufacturer’s specified temperature limits for the project conditions:
      a. Provide cooling device alarm.

B. Power Disconnect:
   1. Flange mounted thermal magnetic circuit breaker:
      a. Lockable in the OFF position.

C. Phase Shifting Transformer:
   1. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
   2. Rated for rectifier duty.
   3. Copper windings with 220 degree Celsius insulation.

D. Reactors:
   1. Furnished with a three percent output line reactor.

E. Keypad:
   1. Furnished with a keypad for programming and control.
   2. Password security to protect drive parameters.
   3. Mounted on the door of the VFD.
   4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
   5. Programming and Display Features Language: English.
   6. Capable of Displaying the Following Parameters:
      a. Speed (percent).
      b. Output current (Amperes).
      c. Output frequency (Hertz).
      d. Input voltage.
      e. Output voltage.
      f. Total 3-phase kilowatt.
      g. Kilowatt hour meter.
      h. Elapsed run time meter.
      i. Revolutions per minute.
      j. Direct current bus voltage.
   7. In addition to all keys required for programming, the keypad shall have the following:
      b. Start pushbutton.
c. Stop pushbutton.
d. Jog pushbutton.
e. Speed increment.
f. Speed decrement.
g. RUN led indicator.
h. PROGRAM led indicator.
i. FAULT led indicator.

8. Provide the VFD with the Following Controls:
   a. Start pushbutton.
   b. Stop pushbutton.
   c. Jog pushbutton.
   d. Emergency Stop mushroom head pushbutton.
   e. Hand/Off/Automatic selector switch.
   g. Control Power On pilot light.
   h. Run pilot light.
   i. Motor Fault pilot light.
   j. Speed potentiometer.
   k. Elapsed time meter.
   l. VFD/Bypass selector switch.
   m. VFD Mode pilot light.
   n. Bypass Mode pilot light.

F. Control Power Transformer:
   1. Furnish a control power transformer mounted and wired inside the drive enclosure.
   2. Primary and secondary fusing.
   3. Size the transformer to supply power to all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

G. VFD Input Contactor:
   1. The VFD shall be provided with a contactor between the incoming power and the VFD:
      a. The VFD shall be provided with all circuitry to control the contactor. On motor start, the VFD shall close the input contactor.
      b. After the motor is stopped, the VFD shall open the input contactor.

H. VFD Output Contactor:
   1. The VFD shall be provided with a contactor between the VFD output and the motor:
      a. The output contactor shall close when the VFD is energized and open on a drive fault or loss of power condition.

I. Bypass Starter:
   1. Where indicated on the Drawings, the VFD shall be furnished with an integral reduced voltage solid state bypass starter.
   2. Motor overload protection for bypass operation shall be provided.
   3. Mechanically/electrically interlocked contactors for bypass operation shall be provided.
   4. A VFD/Off/Bypass selector switch shall be provided on the VFD front panel.
2.04 ACCESSORIES

A. Metal Oxide Varistors:
   1. Provide Protection for the VFD Against:
      a. Line Transients: 5,000 volt peak minimum.
      b. Line to Ground Transients: 7,000 peak minimum.

2.05 FINISHES

A. Enclosure finish shall be ANSI 61.

2.06 SOURCE QUALITY CONTROL

A. Variable Frequency Drives, Factory Testing:
   1. General:
      a. Incoming inspection of components and raw materials based on strategic
         supplier base and experience.
      b. All variable frequency drives furnished under this section shall be tested
         and inspected as specified below. Testing of variable frequency drives
         based on sampling plans is not allowed.
      c. The testing procedures specified are the minimum acceptable
         requirements. The manufacturer may perform additional tests at its
         discretion.
   2. Failure of any component during testing requires repair of the faulted
      component and complete retest.
   3. Testing Sequence:
      a. Submit a Detailed Test Procedure for the VFD Factory Test:
         1) A minimum of 8 weeks in advance of the proposed testing date.
         2) No tests shall be performed until the test procedure is reviewed and
            accepted by the ENGINEER.
   4. Component Tests:
      a. Preliminary Inspection:
         1) Verify that all components are correct.
         2) Verify that all connections are properly torqued.
      b. Printed Circuit Boards:
         1) Test for correct component placement and value and complete board
            functional test to ensure proper performance with specified
            tolerances.
         2) Heat cycle test for 48 hours at 60 degrees Celsius.
         3) Apply control power to microprocessors, printed circuit boards,
            diagnostic boards, and similar devices including software to test for
            proper operation, sequencing, logic, and diagnostics.
         4) Test operation of all analog and discrete inputs and outputs.
      c. Wiring:
         1) Control and power wiring continuity verified point-to-point.
         2) Hi-pot power and control wiring at manufacturer’s recommended
            levels.
         3) Verify ground bond resistance.
      d. Load Testing:
         1) No load testing in accordance with the manufacturer's standard
            factory test procedure.
         2) Full Load Testing:
a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
b) Load test each VFD at an ambient temperature of 40 degrees Celsius.
c) Monitor and Record Temperature Rise:
   (1) If temperature rise exceeds the rated value, repair or replace the VFD and retest.
d) Once temperature rise stops continue to operate the VFD for a minimum of 2 hours.

PART 3 EXECUTION

3.01 INSTALLATION

   A. Refer to Section 16050.

   B. Install the VFD per the manufacturers guidelines and submitted installation instructions to meet the seismic requirements at the project site as defined in Section 01612.

   C. General:
      1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing).
      2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
      3. Perform work in accordance with the manufacturer’s instructions and shop drawings
      4. Furnish components, and equipment as required to complete the installation.
      5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
      6. Install free-standing enclosures on 3 1/2 inch raised concrete house keeping pad:
         a. Provide structural leveling channels in accordance with the manufacturer’s recommendations to provide proper alignment of the units.
         b. Weld and/or bolt the VFD frame to the leveling channels.
      7. Provide openings in top or bottom of the VFD (free-standing) enclosure for conduit only, no additional openings will be allowed:
         a. Improperly Cut Holes will Require that the Entire Panel be Replaced:
            1) No hole closers or patches will be allowed.
      8. Bundle Circuits Together and Terminate in Each Unit:
         a. Tie with nylon wire ties. Refer to Section 16123.
         b. Label all wires at each end with wire numbers shown on the approved control Drawings.
         c. All connections to and from the VFD (free-standing) enclosure must be made via terminal blocks.

3.02 FIELD QUALITY CONTROL

   A. Refer to Section 16050.
B. Provide the services of a VFD manufacturer representative for startup assistance and training:

1. Inspection and Field Adjustment:
   a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.

2. Start-Up Field Testing:
   a. Provide technical direction for testing, checkout, and startup of the variable frequency drive equipment in the field.
   b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
   c. Compliance with the harmonic limit specifications shall be verified by the VFD manufacturer:
      1) Field measurements shall be made at the point of common coupling with and without the VFDs in operation.
      2) Measurements shall be made at rated speed and rated power.
      3) Harmonic testing shall be made with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages.
      4) VFDs not meeting the harmonic specifications shall be repaired or replaced at the OWNER’s discretion.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameter and protective device settings:
   1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
   2. Provide Documentation of VFD Settings Included but Not Limited to:
      a. Minimum speed.
      b. Maximum speed.
      c. Skip speeds.
      d. Current limit.
      e. Acceleration time.
      f. Deceleration time.

3.04 CLEANING

A. Refer to Section 16050.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Demonstrate the operation to the ENGINEER's and OWNER's satisfaction.

C. Training:
   1. Provide instruction of the OWNER’s operation and maintenance staff on the operation and maintenance of the VFD.
   2. Separate classes shall be held for the operations staff and maintenance staff:
a. Operations staff training shall consist of two identical training sessions, each consisting of 1 session per day for 2 days, with each session lasting 4 hours for a total class time of 16 hours:
   1) The sessions shall be scheduled with the OWNER to ensure all operators have the opportunity to attend.
b. Maintenance staff training shall consist of 1 session per day for 2 days with each session lasting for 8 hours, for a total class time of 16 hours.
c. Instruction shall occur at the OWNER’s facility and shall utilize the actual VFDs installed at the site.

3.06 PROTECTION

   A. Refer to Section 16050.

END OF SECTION
SECTION 16272
DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Enclosed Dry-Type Transformers:
      a. Stand alone units.
      b. Units located in packaged power supply centers.
      c. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      d. Primary voltage 600 volts and below.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.

C. National Electrical Manufacturers Association (NEMA):
   1. ST-20 - Dry-Type Transformers for General Applications.

D. Underwriters Laboratory (UL):
   1. 1561 - Standard for Safety for Dry-Type General Purpose and Power Transformers.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTIONS

A. Provide 3-phase, or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
1. Transformers shall provide full capacity at the project elevation and environmental conditions as specified in Section 16050 after all derating factors have been applied.

2. Suitable for continuous operation at full rating with normal life expectancy as defined in ANSI C57.96.

1.05 SUBMITTALS

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

B. Product Data:
   1. Catalog cut sheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Inrush current.
   5. Insulation system and temperature constraints.
   6. Number and rating of taps.
   7. Sound levels.
   8. Connections:
      a. Primary.
      b. Secondary.
   9. BIL rating.
   10. Required clearances.
   11. Percent impedance.
   12. Efficiency.
   13. Certification of full capacity capability at the project elevation and ambient conditions.

C. Installation Instructions:
   1. Provide anchorage instructions and requirements for the transformer based on the seismic conditions of the site as specified in Section 01612.
   2. Drawings and calculations stamped and signed by a Professional Engineer registered in the State where the project is located.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 WARRANTY

A. Refer to Section 16050.
1.10 SYSTEM START UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following or Equal:
   1. General Electric.
   3. Square D.
   4. Eaton-Cutler Hammer.
   5. ABB.

2.02 (NOT USED)

2.03 MATERIALS

A. Cores:
   1. Non-aging, grain-oriented silicon steel.
   2. Magnetic flux densities below the saturation point.

B. Windings:
   1. High-grade magnet wire.
   2. Impregnated Assembly with Non-Hydroscopic, Thermo-Setting Varnish:
      a. Cured to reduce hot-spots and seal out moisture.
   3. Material Electrical Grade:
      a. Copper.

2.04 EQUIPMENT

A. General:
   1. Ten kilovolts BIL for 600-volt class windings.
   2. Sound Levels, Under ANSI Standard C89 Test Conditions, Not to Exceed:

<table>
<thead>
<tr>
<th>Kilovolt-Amperes Range</th>
<th>Audible Sound Level (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>40</td>
</tr>
<tr>
<td>10-50</td>
<td>45</td>
</tr>
<tr>
<td>51-150</td>
<td>50</td>
</tr>
<tr>
<td>151-300</td>
<td>55</td>
</tr>
<tr>
<td>301-500</td>
<td>60</td>
</tr>
<tr>
<td>501-700</td>
<td>62</td>
</tr>
<tr>
<td>701-1000</td>
<td>64</td>
</tr>
</tbody>
</table>

   3. Taps:
      a. Fifteen kilovolt-amperes and less:
         1) Two 5 percent full capacity primary taps below rated voltage.
      b. Twenty-five kilovolt-amperes and larger:
         1) Four 2.5 percent full capacity primary taps below rated voltage.
         2) Two 2.5 percent full capacity primary taps above rated voltage.
      c. Operated by a tap changer handle or tap jumpers accessible through a panel.
4. Terminals:
   a. UL listed for either copper or aluminum conductors.
   b. Rated for 75 degrees Celsius.
5. Daily overload capacities, at rated voltage and without reduction in life, in
   accordance with the loading guide as published in ANSI C57.96.

B. Transformers Less than 15 Kilovolt-Amperes:
   1. Insulation Class: 185 degrees Celsius.

C. Energy Efficient Transformers 15 kilovolt-amperes and larger:
   1. Insulation Class: 220 degrees Celsius.
   2. Temperature rise: 115 degrees Celsius, except as noted below:
      a. 150 degree Celsius rise for dry-type transformers located in Motor Control
         Centers.
   3. Efficiency:
      a. As specified in NEMA TP-1-1996.
      b. Measured by NEMA TP-2.

D. Low Temperature Rise Transformers 15 Kilovolt-Amperes and Larger:
   1. Insulation Class: 220 degrees Celsius.
   3. Efficiency:
      a. Minimum of 95 percent for 80 degree rise.
      b. Minimum of 96 percent for 115 degree rise.

E. Enclosures:
   1. Heavy Gauge Steel:
      a. Indoor NEMA 1
   2. Louvers to limit coil temperature rise to the value stated above, and case
      temperature rise to 50 degrees Celsius.
   3. Built-In Vibration Dampeners to Isolate the Core and Coils from the Enclosure:
      a. Neoprene vibration pads and sleeves.

2.05 ACCESSORIES

A. Nameplates:
   1. Non-Corrosive Metal or UL Listed Non-Metallic:
      a. Stamped, Engraved or Printed with the Following Information:
         1) Phases.
         2) Frequency.
         3) Kilovolt-ampere rating.
         4) Voltage ratings.
         5) Temperature rise.
         6) Impedance.
         7) Insulation class.
         8) BIL rating.
         9) Weight.
         10) Manufacturer.
         11) Other information required by NEMA ST 20.
2.06 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited ANSI 61 gray enamel rust-inhibiting paint.

2.07 SOURCE QUALITY CONTROL

A. Factory Tests:
   1. Applied Voltage Test to Each Winding and from Each Winding to the Core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
   5. Perform all tests in accordance with NEMA ST-20.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. General:
   1. Floor, wall, platform, packaged power supply, as indicated on the Drawings.
   2. Locate where not in direct contact with building structure.
   3. Install on Korfund Series F or H double-deflection mounts selected for maximum isolation.
   4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
   5. Ground the Enclosure:
      a. To an equipment ground conductor in the conduit.
      b. To the facility grounding electrode system.
   6. Floor Mounted Transformers:
      a. Install transformers on 3-1/2 inch housekeeping pads.
      b. Install transformers from walls or other enclosures for proper ventilation in accordance with the manufacturer’s recommendations.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 ADJUSTING

A. Set the transformer taps, as required to obtain nominal output voltage on the secondary terminals.

3.04 CLEANING

A. Refer to Section 16050.
3.05 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16285
TRANSIENT VOLTAGE SURGE SUPPRESSORS

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes Requirements for:
   1. High-energy transient voltage surge suppression systems.

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

1.02 REFERENCES
A. Refer to Section 16050.

1.03 DEFINITIONS
A. Refer to Section 16050.

B. Specific Definitions:
   1. TVSS - Transient Voltage Surge Suppression.
   2. SAD - Silicon Avalanche Diode.
   3. MOV - Metal Oxide Varistor.

1.04 SYSTEM DESCRIPTION
A. TVSS modules as an integral component of the electrical equipment or externally
   mounted as indicated on the Drawings.

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

B. Product Data:
   1. Furnish complete product data confirming detailed compliance or exception
      statements to all provisions of this Specification.
   2. Submit independent test data from a nationally recognized testing laboratory
      verifying the following:
      a. Lifecycle testing.
      b. Overcurrent protection.
      c. UL 1449.
      d. Surge current capacity.
C. Shop Drawings:
   1. Provide Electrical and Mechanical Drawings by the Manufacturer that Detail:
      a. Unit dimensions.
      b. Weights.
      c. Components.
      d. Field connection locations.
      e. Mounting provisions.
      f. Connection details.
      g. Wiring diagram.

D. Operation and Maintenance Manuals:
   1. Provide the manufacturer’s manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Provide TVSS units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. Institute of Electrical and Electronic Engineers (IEEE C62.41, C62.45).

C. TVSS Manufacturer: ISO 9001 certified for manufacturing, design, and service.

D. Provide a transient voltage suppression system that is suitable for application in IEEE C62.41 Category A, B and C3 environments, as tested by IEEE C2.11, C62.45.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 SEQUENCING

A. Coordinate with, and provide TVSS equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

A. Refer to Section 16050.

B. Extended Warranty:
1. Furnish a manufacturer’s full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer’s written instructions, UL Listing requirements, and any applicable national, state, or local electrical codes.

2. Warranty shall include:
   a. Direct, factory trained, ISO 9001 certified employees must be available within 48 hours for assessment of the problem.
   b. A 24-hour toll-free 800-number for warranty support.

1.11 SYSTEM STARTUP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the Following or equal:
   1. Liebert.
   2. Eaton-Cutler Hammer.
   3. Square D.

2.02 MANUFACTURED UNITS

A. Electrical Requirements:
   1. TVSS ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
   2. Maximum Continuous Operating Voltage (MCOV):
      a. For the TVSS and all components in the suppression path (including all MOVs, SADs, and selenium cells): greater than 115 percent of the nominal system operating voltage.
   3. Operating Frequency:
      a. Forty-seven to 63 hertz.
   4. Short Circuit Rating:
      a. Minimum TVSS rating of 200,000 AIC at system voltage without the use of a fused disconnect switch.

B. Protection Modes:
   1. Provide TVSS protection modes as follows:
      a. Line to Neutral (L-N) where applicable.
      b. Line to Ground (L-G).
      c. Neutral to Ground (N-G), where applicable.

C. The following table details the maximum UL 1449 2nd Edition Suppressed Voltage Rating (SVR). The TVSS unit, including disconnect for each of the specified protection modes, shall not exceed the following:
## Nominal Voltage Configuration (Volts)

<table>
<thead>
<tr>
<th>Wye Models</th>
<th>Nominal Voltage</th>
<th>Configuration</th>
<th>L-N (Volts)</th>
<th>N-G (Volts)</th>
<th>L-G (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/240</td>
<td>Grounded Neutral</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>120/208</td>
<td>Grounded Wye</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>277/480</td>
<td>Grounded Wye</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>347/600</td>
<td>Grounded Wye</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>DELTA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>Delta</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>480</td>
<td>Delta</td>
<td>1500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>Delta</td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### D. Environmental Requirements:
1. Storage Temperature:
   a. Minus 40 degrees to +60 degrees Celsius.
2. Operating Temperature:
   a. Minus 20 degrees to +60 Celsius.
3. Relative Humidity:
   a. Five percent to 95 percent.
4. Audible Noise:
   a. Less than 45 dBA at 5 feet (1.5 m).
5. Operating Altitude:
   a. Zero to 12,000 feet above sea level.

### E. Enclosure:
1. Located in electrical equipment as indicated on the Drawings.
2. External mounting:
   a. NEMA 12 enclosure:
      1) No ventilation openings.
   b. Hinged cover requiring a tool for internal access.
   c. Internal drawing pocket.
   d. All monitoring indications must be visible without opening the door.

### F. Internal Connections:
1. Provide Low Impedance Copper Plates for Intra-Unit Connections:
   a. Attach surge modules using bolted connections to the plates for low impedance connections.
2. Size all connections, conductors, and terminals for the specified surge current capacity.

### 2.03 COMPONENTS

#### A. Surge Diversion Modules:
1. Metal Oxide Varistors (MOV):
   a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer’s defects.

#### B. Overcurrent Protection:
1. Individually fuse all components, including suppression, filtering, and monitoring components:
a. Rated to allow maximum specified surge current capacity:
   b. For every 100 kiloamperes of Surge Current Capacity, provide 120 amps
      RMS of internal fusing.

2. Fuse individual surge components at a maximum of 7-1/2 amps to prevent
   violent failure:
   a. UL listed to be capable of interrupting up to 100 kiloamperes symmetrical
      fault current with 600 VAC applied.
   b. Replaceable fusing is unacceptable.
   c. Overcurrent protection that limits specified surge currents is not acceptable.

C. Connections:
   1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.04 ACCESSORIES

A. Unit Status Indicators:
   1. Provide red and green solid-state indicators, with printed labels, on the hinged
      front cover to redundantly indicate on-line unit status:
      a. The absence of the green light and the presence of the red light indicates
         that surge protection is reduced and service is needed to restore full
         operation.

B. Dry Contacts for Remote Monitoring:
   1. Electrically isolated Form C dry contacts (10A/125VAC) for remote monitoring of
      system integrity, and indication of under voltage, phase, and/or power loss.

C. Provide on-line circuit which tests and redundantly monitors individual components in
   all protection modes including neutral to ground:
   1. Units that require external test sets or equipment are unacceptable.

D. Provide a self-contained remote monitoring panel to allow remote annunciation of the
   system status:
   1. Input Power to the Monitoring Panel: Provide a 6 foot input power cord with a
      NEMA 5-15 plug.
   2. Provide an audible alarm, red and green LEDs, an alarm On/Off switch to
      silence and a push-to-test alarm switch.

E. Provide an integral disconnect switch located in-line with the TVSS system enclosure:
   1. External manual operator.
   2. The switch shall disconnect all ungrounded circuit conductors from the TVSS.
   3. The integral disconnect switch shall be capable of withstanding, without failure,
      the maximum published surge current magnitude and short circuit current
      without failure or damage to the switch.

2.05 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the TVSS.

B. Duty life cycle test the TVSS system to survive 20 Kilovolts, 10 kiloamperes, IEEE
   C62.41 Category C3 surge current with less than 5 percent degradation of clamping
   voltage. In compliance with the following table:
<table>
<thead>
<tr>
<th>Device Surge Rating</th>
<th>Minimum Number of Life Cycle Surges Per Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Mode</td>
<td>Per Phase</td>
</tr>
<tr>
<td>200 kA</td>
<td>400 kA</td>
</tr>
</tbody>
</table>

C. Test the system at the component and fully assembled level, under surge conditions with alternating current power applied for a minimum of 1 hour:
1. Testing Includes but Not Limited to:
   a. Quality control checks.
   b. Dielectric voltage withstand test per UL requirements.
   c. UL ground continuity tests.
   d. Operational and calibration tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Special Techniques:
1. Install the TVSS with as short and straight conductors including ground conductor as practically possible.
2. Twist the TVSS input conductors together to reduce input conductor inductance.
3. Follow the TVSS manufacturer's recommended installation practices and comply with all applicable codes.
4. Interconnect the TVSS to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
5. Do not subject TVSS to insulation resistance testing.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16950.

3.03 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16290
POWER MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
1. Supply and installation of a complete Electrical Power Monitoring System (EPMS) including, but is not limited to:
   a. Power meters for power monitoring.
   b. Device communication interface hardware.
   c. Communication wiring.
   d. Software.
   e. Ancillary equipment.
   f. Start-up services.
   g. Training services.
2. EPMS capable of future interconnection with the Supervisory Control and Data Acquisition system (SCADA) via the network.
3. Power metering is not specifically shown on the One-Line Diagrams; however, complete power metering of the main device is required for in plant use and shall be incorporated into the main switchgear.

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

1.02 REFERENCES

A. Refer to Section 16050.
B. American National Standard Institute (ANSI):
   1. The EPMS shall comply with the applicable portions of ANSI/IEEE 802.3
   2. Meters shall have certified revenue accuracy per ANSI C12.20 and IEC 60687 Class 0.5S or better.

1.03 DEFINITIONS

A. Refer to Section 16050.
B. Specific Definitions:
   1. EPMS - Electrical Power Monitoring System.
   2. Master Control Unit - Personal Computer(s) (PC) used for EPMS data gathering, typically located in a central control room. Units may or may not be the same as the SCADA computers.
   3. FS - Full Scale.
   4. PLC - Programmable Logic Control.
   5. RDG - Of Reading.
6. SSM - Solid State Multifunction Power Meter.
7. THD - Total Harmonic Distortion.

1.04 SYSTEM DESCRIPTION

A. The EPMS system, including hardware and software, shall be capable of displaying the information from the main circuit breaker.

1.05 SUBMITTALS

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

B. Product Data:
   1. System description including an overview of the system provided with detailed description of system architecture, system noise immunity, and data provided.
   2. Bill of Material Including a Complete Listing of All Hardware, Software:
      a. Interface method(s) with the plant PLC and SCADA system(s).
   3. Block Diagram Depicting Information Including but Not Limited to:
      a. Assemblies/Devices to be connected to the system.
      b. Types of wiring (twisted pair, coaxial, fiber, etc.)
   4. Narrative detailing the training and start-up services being supplied.
   5. Hardware description shall be provided in detail for all communications hardware and/or software, including sensor devices gathering data to be transmitted over the network, and master display unit.
   6. Detailed Information Including but Not Limited to:
      a. Communication cable.
      b. Cable ratings.
      c. Communication characteristics.
      d. Termination requirements.
      e. Splicing/connections requirements.

C. Shop Drawings:
   1. Detailed wiring diagrams with wire numbers showing all interconnections within and between the electrical equipment housing the power monitoring equipment.
   2. Detailed communication wiring diagrams.
   3. Cable routing.

D. Operation and Maintenance Manuals:
   1. System description overview for the complete system, descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
   2. A maintenance section including all instruction leaflets and technical data necessary to setup, change setup and maintain the communicating devices and sensors.
   3. Original licensed copies of all software and software manuals.
   4. A detailed start-up report, including a list of individuals who attended system training shall be provided.

E. Record Documents:
   1. Detailed record drawings concerning communication wiring shall include but not be limited to:
a. System overview with descriptive manuals covering each component within the system.
b. Maintenance section(s) including instruction and technical data necessary to setup and modify equipment and communications.
c. Original licensed copy of all software manuals.
d. Communications Sections shall Include as a Minimum:
   1) Type of communication wire utilized.
   2) General cable ratings and communications characteristics.
   3) Cable routing diagram including terminations, and splicing connections made.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Qualifications:
   1. The manufacturer of the equipment shall have been regularly engaged in the manufacture of the specified devices for a period of at least 5 years and demonstrate that these products have been in satisfactory use in functioning systems for similar design, application, installation, and start-up.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 WARRANTY

A. Refer to Section 16050.

1.10 SYSTEM START-UP

A. Refer to Section 16050.

1.11 MAINTENANCE

A. Spare Parts shall Include but Not be Limited to:
   1. One of each type of line drivers.
   2. One of each type of power supply.
   3. One of each type of network interface card.
   4. One of each type of repeater.
   5. Three of each type of data line surge suppressors.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Shall be of the same manufacturer as the switchgear or equipment housing the EPMS equipment or for which power is being measured.
2.02 COMPONENTS

A. Power Meters:
   1. Power Meter Analyzer Device which shall Include at a Minimum:
      a. Individual phase currents, plus or minus 0.2 percent FS.
      b. Phase-to-phase and phase-to-neutral voltages, plus or minus 0.2 percent FS.
      c. Watts, VARs, VA, plus or minus 0.4 percent FS.
      d. Watt-Hours 0.5 percent OR; VAR-Hours 1 percent OR; VA-Hours 0.5 percent OR;
      e. PF Apparent 0.8 percent FS; PF Displacement 0.8 percent FS.
      f. Frequency, 0.04 percent, or 0.01 Hz.
      g. THD:
         1) Voltage - 50th harmonic.
         2) Current - 50th harmonic.
      h. Demand:
         1) Ampere, plus or minus 0.2 percent FS.
         2) Watt, VAR, VA, plus or minus 0.4 percent FS.
      i. Revenue accuracy per ANSI C12.16 (0.5 percent) and C12.20 (0.5 percent).
      j. Minimum and Maximum Values:
         1) Volts (L-L), Volts (L-N), Current (L, N, G), Watts, VARs, VA.
         2) PF (Apparent and Displacement.)
         3) Frequency.
         4) THD-Amps, THD-Volts.
         5) Demand:
            a) Ampere, Watt, VAR, VA.
      k. Trend Analysis:
         1) Time/Date.
      l. Event Logging:
         1) Five hundred and four Events with time stamp.
      m. Disturbance Recording:
         1) Ten Waveform Events.
      n. Inputs/Outputs:
         1) Four Form C relays, rated 10 amps.
         2) Four 0-10/4-20 mA analog outputs.
         3) Three +30 VDC differential discrete inputs.
         4) One 0-20/4-20 mA analog input.
      o. Kilowatt hour pulse initiator.
      p. Waveform display - local / computer.
      q. Frequency distribution display - local / computer.
      r. Graphic LCD with LED Backlight:
         1) Seven lines, 147 characters.
      s. Manufacturers:
         1) Eaton Cutler-Hammer type IQ Analyzer-6000.
         2) GE type PQM.
         3) Square D type CM 4000, 0.2 percent Accuracy.

2.03 ACCESSORIES

A. Current Transformers:
1. Ring Type Current Transformers:
   a. Suitable for service within low or medium voltage switchgear as indicated on the Drawings.
   b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the circuit breaker of the application.

2. Current Ratio:
   a. It is the Switchgear manufacturer’s responsibility to size the current transformers to ensure that they will not saturate under the maximum available fault current at the installed location based upon the fault current study as performed under Section 16305.

3. Rated in accordance with ANSI Standard C57.13 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.

4. Identify polarity with standard marking or symbols.

5. Capable of carrying rated primary current continuously without damage.

6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

7. Located behind the breaker compartment mechanical safety shutter and shall be front accessible once the safety shutter is removed.

B. Potential Transformers:
   1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 Celsius rise above 40 Celsius ambient.
   2. Accuracy classification determined according to ANSI Standard C57.13, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
   3. Insulation levels as required for the switchgear system voltage but not less than:
      a. 600 VAC, 10 kV BIL for 480 VAC systems.
      b. 5.6 KV, 60 kV BIL for 2300 and 4160 VAC systems.
      c. 15.5 KV, 110 kV BIL for 12.47kV and 13.2 kV systems.
   4. Identify polarity with standard markings or symbols.
   5. Connect transformer secondary to potential buses as required.
   6. Protect medium voltage potential transformers on the primary side with medium voltage current-limiting fuses.
   7. Protect low voltage potential transformers on the primary side and secondary side with current-limiting fuses.
   8. Mount medium voltage potential transformers in a separate compartment on a drawout device which, when in the FULLY WITHDRAWN position, disconnects both primary and secondary terminals of the transformer and grounds the primary potential fuses.

2.04 SOURCE QUALITY CONTROL

A. Factory Testing:
   1. The entire EPCMS system shall be fully configured and tested with all actual devices furnished at the manufacturer’s facility, and said test shall be witnessed by the ENGINEER.
B. Standard Factory Tests shall Include, but Not be Limited to:
   1. Configure and load all software.
   2. Test and operate for minimum of 24 hours, EPMS devices, computer, and software in a mode that replicates the plant hardware, software, and actual configuration:
      a. The simulation shall reflect the actual types and configuration of EPMS devices to be used in the project.
   3. Demonstrate full system functionality.
   4. Inject current and apply appropriate voltages to confirm operation and accuracies.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. The CONTRACTOR shall furnish, install, and terminate all communication conductors and associated conduits external to any factory supplied equipment.

C. All communications conductor wiring and routing shall be per the manufacturer's recommendations and as shown on the submittal drawings.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. Furnish the services of a manufacturer's field engineer to assist in starting-up and programming the system:
   1. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware, and system programming.
   2. The Manufacturer's Representative shall Provide the Following Services:
      a. Verifying the setting of all the addresses for all devices in the equipment.
      b. Verifying and troubleshooting the integrity of the communications line.
      c. Assisting in correcting any communication line problems.
      d. Verify that the EPMS software matches the field devices.
   3. Verify complete system operation including all hardware, software, and communication devices.
   4. Verify networking performance with all interfacing systems by other manufacturers.

C. The manufacturer's field engineer shall visit the site for a second time when the plant is loaded and operating and shall ensure the EPMS is operating properly. Documentation of EPMS performance shall be furnished to the OWNER.

D. Certification:
   1. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.
E. After Start-Up Support:
   1. The EPMS manufacturer shall provide a 24-hour 800-telephone number manned with Engineers/Technicians expert in EPMS devices, software, and communication system troubleshooting or capable of providing technical information.
   2. The EPMS manufacturer shall provide normal 8-hour workday dial-in interface capability to aid in diagnosing system problems. Provide phone modem in Master personal computer.

3.03 CLEANING
   A. Refer to Section 16050.

3.04 DEMONSTRATION
   A. Refer to Section 16050.
   B. Training:
      1. Furnish the services of a manufacturer's representative for a period of three 8-hour days to train the OWNER's personnel in operation and programming of the system.
      2. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware, and system programming.
      3. The training session shall be provided for approximately 5 people and shall include:
         a. Hands-on training of site personnel.
         b. Explanation of system operation.
         c. Explanation of devices.
         d. Explanation of the system as installed.
         e. Detailed Software Training Including:
            1) Adding or deleting devices.
            2) Programming alarms.
            3) Developing graphics.
      4. Generating reports.
      5. CONTRACTOR shall record the training sessions and provide to the OWNER 6 DVD compatible formatted copies.

3.05 PROTECTION
   A. Refer to Section 16050.

END OF SECTION
SECTION 16305
ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:
   1. Short Circuit Fault Analysis Study and Protective Devices Coordination Study:
      a. The protective device coordination study includes protective device
         settings for all functions indicated on the Drawings, including, but not
         limited to:
         1) Current.
         2) Voltage.
         3) Frequency.
         4) Negative sequence.
         5) Machine protection functions.
   2. Arc-Flash Hazard Study.
   3. Facility Harmonic Study.
   4. Facility Power Factor Study

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

1.02 REFERENCES

A. Refer to Section 16050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 141 - IEEE Recommended Practice for Electric Power Distribution for
      Industrial Plants.
   2. 242 - IEEE Recommended Practice for Protection and Coordination of
      Industrial and Commercial Power Systems (Buff Book).
   3. 399 - IEEE Recommended Practice for Industrial and Commercial Power
      Systems Analysis (Brown Book).
   4. 1015 - IEEE Recommended Practice For Applying Low Voltage Circuit
      Breakers Used in Industrial and Commercial Power Systems - Corrigendum 1.
   6. IEEE Standards Electrical and Electronics Graphic and Letter Symbols and
      Reference Designations.
   7. IEEE Red Book - IEEE Recommended Practice for Electric Power Distribution
      for Industrial Plants.
   8. IEEE Yellow Book - IEEE Guide for Maintenance, Operation and Safety on
      Industrial and Commercial Power Systems.
C. National Fire Protection Association (NFPA):
   1. 70E - Standard for Electrical Safety in the Workplace.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. General Study Requirements:
   1. Obtain, for all equipment, the required field data for preparation of the study.
      This shall include, but not limited to:
      a. Transformer kilovolt-ampere and impedances.
      b. Bus withstand ratings.
      c. Cable and bus data.
      d. Protective device taps, time dials, instantaneous pickups, and time delay
         settings.
   2. Obtain the Electric Utility information on the available fault current, utility
      protective device settings including manufacturer and model number,
      interrupting ratings, X/R ratios, and model information one level above the
      point of connection:
      a. Utility tolerances and voltage variations.
   3. The individual performing the arc-flash hazard study shall visit the site and
      collect all necessary field data in order to perform and complete a
      comprehensive arc-flash hazard study.
   4. Obtain equipment layouts and configurations from the manufacturer’s final
      submittal requirements and project layout drawings as required.
   5. The short-circuit fault and coordination study shall include all equipment in the
      power distribution system. Study scenarios shall include, but not be limited to:
      b. Motor contribution.
      c. Other separately derived sources.
      d. Normal system connections and those that result in maximum fault
         conditions shall be covered in the study.
   6. The scope of the Arc-Flash Hazard Study shall be as defined for the
      short-circuit fault and coordination study. In addition, the Arc-Flash Hazard
      Study shall include all 240 volt and 208 volt systems.
   7. Equipment and Conductor Data:
      a. Use impedances based on actual installed or specified conductors, unless
         otherwise indicated.
      b. Use cable and bus resistances calculated at 25 degrees Celsius, unless
         otherwise indicated.
      c. Use 600-volt cable reactance based on typical dimensions of actual
         installed or specified conductors, unless otherwise indicated.
      d. Use bus withstand values for all equipment having buses.
      e. Use medium voltage cable reactances based on typical dimensions of
         shielded cables with 133 percent insulation levels, unless otherwise
         indicated.

B. Short-Circuit Fault Analysis Study Requirements:
   1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
      a. Initial Short-Circuit Fault Analysis:
1) Based on the Contract Documents and Electric Utility information.
2) The initial short-circuit fault analysis report shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
3) Provide a list of assumptions used in the initial study.

b. Final Short-Circuit Analysis:
   1) The final short-circuit fault analysis shall modify the initial analysis as follows:
      a) Utilize the actual equipment provided on the project.
      b) Utilize conductor lengths based on installation.

2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 and 4 cycle, interrupting symmetrical RMS, and 30 cycle steady state short circuit current values at each switchgear, switchboard, motor controller, distribution panelboard, branch circuit panelboard, other overcurrent protective devices, disconnect switches and motors located throughout the distribution system.

3. Evaluate bus bracing, short circuit ratings, fuse interrupting capacity and circuit breaker adjusted interrupting capacities against the fault currents, and calculate X/R values. Flag inadequate devices and document all acceptable devices and equipment.

4. Calculate line-to-ground and double line-to-ground momentary short circuit values at all buses having ground fault devices.

5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including Utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective Device Coordination Study Requirements:
   1. Provide log-log form time-current curves (TCC’s) graphically indicating the coordination proposed for the system:
      a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC.
      b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. These details can be included on the TCC.
      c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings. These details can be included in the TCC.

   2. TCC’s shall include new, modified and existing equipment in the power distribution system where required to demonstrate coordination. This shall include Utility relay and fuse characteristics, medium voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
      a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards and fused disconnect switches.
      b. Provide ground fault TCC’s with all adjustable settings for ground fault protective devices.
      c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
d. On the TCC’s show transformer full load currents, transformer magnetizing inrush, and ANSI transformer withstand parameters.
e. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.

3. Suggest modifications or additions to equipment rating or settings in a tabulated form.
4. Cable damage curves.
5. Transformer damage curves.
6. Voltage and Frequency Relays:
a. Provide settings for all voltage and frequency relays based upon actual Utility and generator tolerances and specifications.
7. Motor Protective Relays:
a. Provide settings for all motor and generator protective relays based on the manufacturer’s recommended protection requirements.

D. Arc-Flash Hazard Study Requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at key points: switchgear, switchboards, motor controllers, panelboards, etc., throughout the scope of the system as defined in this specification:
a. Perform Arc-flash calculations for both the line side and load side of switchgear, switchboard, motor controllers and panelboard main breakers.
b. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
c. Protective device clearing time shall be limited to 2 seconds, maximum.
2. Provide a detailed verbal discussion and explanation of the tabulated outputs.
3. Provide executive summary of the study results.
4. Provide alternative device settings to allow the OWNER to select the desired functionality of the system:
a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. Electrical System Study Meetings:
1. The individual directing the short circuit and protective device coordination study and the arc-flash hazard study shall meet with the OWNER and ENGINEER 3 times.
2. The Purpose of the 3 Meetings is as Follows:
a. Initial Meeting:
   1) Meet with the OWNER and ENGINEER to discuss the scope of the studies.
   2) Discuss the OWNER’s operational requirements for both normal operation and maintenance.
b. Preliminary Results:
   1) This meeting will be held after the studies have been completed, reviewed, and accepted by the ENGINEER.
   2) The purpose of this meeting is to inform the OWNER of the results of the study and impacts on normal operation and maintenance including:
a) Protective device coordination problems and recommended solutions.

b) Explanation of the arc-flash study results and its potential impact on operations.

c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.

c. Final Meeting:
   1) Discuss changes to the reports based on the previous meeting.
   2) Discuss with the OWNER how changes to the electrical system may change the arc-flash hazard category.
   3) Deliver the final electrical system studies report.

3. The Meetings will be at the OWNER’S Facility:
   a. Provide a minimum of 3 weeks notice to the OWNER and ENGINEER in advance of the projected meeting date.

4. By virtue of the fact that this is a professional study and that the OWNER has the right to modify the requirements of the study to comply with its operational requirements, the protective device coordination study and the arc-flash study shall be modified based on the results of the meetings with the OWNER.

F. Harmonic Study
   1. Develop a computer based harmonic analysis model of the facility, and investigate all possible operating scenarios to predict the harmonic content of the power system based upon operating loads.
      a. Confirm that the harmonic content is less than that required by IEEE 519-1992.
      b. If the calculated harmonic content is greater than that allowed by IEEE 519-1992 design and provide a harmonic filter to comply with the requirements of IEEE 519-1992.
         1) For the purposes of this study the Point of Common Coupling shall be defined as the connection point to the serving electric utility.

G. Power Factor Study
   1. Develop a computer based model of the facility and calculate the operating power factor for the facility at full anticipated, and at operating load.
   2. Model the proposed power factor correction capacitors along with all harmonic generators to determine the potential for parallel resonance conditions.
      a. Investigate all possible operating scenarios.
      b. If a potential parallel resonance condition can occur, design and provide a low pass filter to achieve the specified power factor and avoid the parallel resonance conditions.
         1) Target power factor = .90

1.05 SUBMITTALS

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

B. Studies and Reports:
   1. Provide six bound copies of all final reports.
   2. The Final Report shall Include the Sections Listed Below:
      a. Copies of correspondence and data obtained from the Electric Utility Company.
b. Letter certifying the inspection and verification of existing equipment.
c. One-line diagrams with all essential short-circuit device information.
d. Short-Circuit Fault Analysis Study shall Include:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those, which result in maximum fault conditions.
   3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
   4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
e. Protective Device Coordination Study shall Include:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) List all requirements used in the selection and setting criteria’s for any protective devices.
   3) Manufacturer’s time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
   4) Time-current curves (TCC’s) graphically indicating the coordination proposed for the system on log-log graphs. At least three of the copies shall be in color.
   5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
   6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
f. Arc-Flash:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those, which result in maximum arc-flash conditions.
   3) Arc-flash raw data, calculations, and assumptions.
   4) Arc-Flash Label Data:
      a) Identifying the content of each label.
      b) Identifying the location of each label.

C. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

D. The ENGINEER will review all studies and reports. After review, the ENGINEER will make recommendations and/or require changes to be made to the short-circuit, coordination and or arc-flash studies. These changes shall be provided as part of the scope of work.

E. Upon completion of all studies provide an electronic copy of the complete power system model and database in a format that is directly usable by the specified distribution system modeling software.

F. Submit course outline for OWNER’S training.
1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Qualifications of the Entity Responsible for Electrical System Studies:
   1. The studies shall be performed, stamped, and signed by a Professional Engineer registered in the state where the project is located.
   2. A minimum of 5 years experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit study, protective device coordination study and arc-flash hazard study shall be performed with the aid of a digital computer program. Point to point calculations are not acceptable.

C. The study shall be performed by an independent firm.

D. Allowable electrical distribution modeling software:
   1. ETAP by Operation Technology, Inc.
   2. Powertools by SKM Systems Analysis.
   4. Or equal.

1.07 SEQUENCING

A. Submit the initial short-circuit study before submittal of any electrical equipment.

B. Submit the final short-circuit study and protective device coordination study.

C. Site visit to gather data on the existing system for the arc-flash study.

D. First arc-flash meeting.

E. Submit the arc-flash hazard study.

F. Second arc-flash meeting.

G. Third arc-flash meeting and final reports.

H. OWNER’s training.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Arc-Flash Hazard Labels:
   1. Dimensions:
      a. Minimum 5 inches by 3.5 inches.
   2. Materials:
      a. Polyester with polyvinyl polymer over-laminate.
      b. Self-adhesive.
      c. Resistant to:
         1) UV.
2) Chemicals and common cleaning solvent resistant.
3) Scuffing.
4) Wide temperature changes.

3. Contents:
   a. Short-circuit bus identification.
   b. Calculated incident energy (calories/square centimeter) range.
   c. Hazard/risk, personnel protective equipment category number.
   d. Arc-flash protection boundary.
   e. Shock Hazard Boundary:
      1) The CONTACTOR may provide separate labels for indication of the shock hazard boundary.
   f. Description of the combined level of personnel protective equipment.

2.02 (NOT USED)

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. After review and acceptance of the arc-flash hazard study by the ENGINEER, install all arc-flash hazard labels:
   1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
   2. At a Minimum Install Labels in the Following Locations:
      a. The front of each main or incoming service compartment.
      b. The front of each low voltage switchgear section.
      c. The front of each accessible auxiliary or conductor compartment.
      d. Each accessible rear or side vertical section.
      e. Each motor controller compartment.
      f. Each panelboard covered by the study.
      g. Each control panel, individual starter or VFD or other equipment covered by the scope of the study.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050:
   1. Test protective devices as specified in Section 16950.
   2. Submit with any related field changes with final copies of studies and documentation.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.
   2. Repair the equipment finish damaged by removal of any label.

3.03 ADJUSTING

A. After review and acceptance of the recommended settings in the Protective Device Coordination Study, make settings in accordance with the manufacturer’s instructions.
3.04 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Training:
   1. Provide a minimum of 2 training sessions for the OWNER’s electrical
      maintenance personnel:
      a. Each session shall be a minimum of 4 hours.
   2. The Training shall Cover at a Minimum:
      a. Hazards associated with arc-flash.
      b. Causes of arc-flash.
      c. Explanation of the arc-flash labels installed on the OWNER’s electrical
         equipment.
      d. Proper use of Personal Protective Equipment.
      e. PPE requirements for maintenance work.
   3. The individual in charge of the arc-flash study or qualified representative shall
      conduct the training sessions.

END OF SECTION
SECTION 16411
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Fusible and non-fusible disconnect switches.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. Underwriters Laboratories Inc. (UL):
   1. UL-20 - UL standards for General-Use Snap Switches.
   2. UL-98 - UL standards for Enclosed and Dead-Front Switches.
   3. UL-508 - UL standards for Industrial Control Equipment.

C. National Electric Manufacturer’s Association (NEMA):
   1. KS 1-2001- Enclosed Disconnect Switches.
   2. 250 - Enclosures for Electrical Equipment.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions:
   1. Safety Switches and Disconnect Switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and in
   the Specifications.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit,
   and horsepower ratings as required by the load and the power system.

C. Provide a local horsepower rated safety switch for each motor indicated on the
   Drawings.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 16050.
B. Product Data:
   1. Manufacturer.
   2. Manufacturer’s specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.
      c. Horsepower.
      d. Short Circuit rating.
   4. Fused or non fused.
   5. NEMA enclosure type.
   6. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   7. Weight.
   8. Cross-referenced to the Disconnect Schedule as indicated on the Drawings.

C. Shop Drawings:
   1. Manufacturer’s Installation Instructions:
      a. Indicate application conditions and limitations of use stipulated by Product
         testing agency specified under Regulatory Requirements.
      b. Include instructions for storage, handling, protection, examination,
         preparation, installation, and operation of product.
   2. Identify motor or equipment served by each switch; indicate nameplate
      inscription.

D. Installation Instructions:
   1. Provide anchorage instructions and requirement based on the seismic
      conditions of the site as specified in Section 01612 and calculations:
      a. Stamped by a Professional Engineer registered in the State where the
         project is being constructed.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Regulatory Requirements:
   1. NEMA KS1- Enclosed Disconnect Switches.
   2. UL 98 - UL standards for Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.
1.09 SEQUENCING

A. Conduct the initial fault current study in accordance with Section 16305 and submit results for ENGINEER’s review.

B. After successful review of the initial fault current study, as required by Section 16305, submit complete equipment submittal in accordance with Paragraph 1.05 of this specification for ENGINEER’s review.

1.10 WARRANTY

A. Refer to Section 16050.

1.11 SYSTEM STARTUP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. Square D Company.
   2. Eaton - Cutler-Hammer.
   4. Siemens.
   5. Appleton.

2.02 EQUIPMENT

A. Switch Mechanism:
   1. Quick-make, quick-break heavy-duty operating mechanisms:
      a. Provisions for padlocking the switch in the OFF position.
      b. A minimum of 90-degree handle travel position between OFF and ON positions:
         1) Handle position indicators to clearly identify if the handle is in the OFF or ON position.
      c. Full cover interlock to prevent opening of the switch door in the ON position and to prevent closing the switch mechanism with the door open:
         1) With an externally operated override.

B. Switch Interior:
   1. Switch blades visible when the switch is OFF and the cover is open.
   2. Lugs, front accessible and removable and UL listed for:
      a. 75 degrees Celsius copper conductors.
   3. Current carrying parts completely plated to resist corrosion.
   4. Removable arc suppressors to facilitate easy access to line side lugs.
   5. Furnish equipment ground kits for every switch.
C. Fused switches:
   1. Furnish with fuses as indicated on the Drawings or when required to meet the available fault current.
      a. Provide fuses in accordance with Section 16434.
      b. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
         1) Ratings 100 amperes thru 600 amperes at 240 volts.
         2) Ratings 30 amperes thru 600 amperes at 600 volts.
         3) Provide spring reinforced and plated fuse clips.

D. Ratings:
   1. UL horsepower rated for AC or DC with the rating not less than the load served.
   2. Current:
      a. 30 to 1200 amperes.
   3. Voltage:
      a. 250 Volts AC, DC.
      b. 600 Volts (30 A to 200 A, 600 Volts DC).
   4. Poles:
      a. 2, 3, 4, and 6 poles.
   5. UL Listed short circuit ratings:
      a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
      b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
      c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1200 amperes).
   6. Where not indicated on the Drawings, provide switches with the NEMA ratings indicated in Section 16050 for the installed location.

E. Size, fusing and number poles as indicated on the Drawings or as required:
   1. Provide solid neutral where indicated on the Drawings.

2.03 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication, as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Install disconnect switches per the manufacturer’s guidelines and submitted installation instructions to meet the seismic requirements at the project as defined in Section 01612.
C. General:
1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA 12, 4, and 4X enclosures.
2. Provide all mounting brackets, stands, supports and hardware as required:
   a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
   b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations as specified in Specification 01612, and locate aboveground or above decks, where there is no structural wall or surface for box.
3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
   a. For NEMA 4 and 4X locations, maintain a minimum of 7/8-inch air space between the enclosure and supporting surface.
   b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
4. Provide a nameplate for each disconnect switch:
   a. Provide per requirements specified in Section 16075.
   b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.02 FIELD QUALITY CONTROL
   A. Refer to Section 16050.

3.03 CLEANING
   A. Refer to Section 16050.

3.04 PROTECTION
   A. Refer to Section 16050.

END OF SECTION
SECTION 16412
LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Low voltage molded case circuit breakers as indicated on the Drawings and as specified.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. AB 1. - Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.
   2. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter’s Laboratories (UL):
   2. UL 943- Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connect to form a completed system:
   1. Molded case circuit breakers used to open and close a circuit, and to open a circuit automatically on a predetermined overload or over current, without damage to itself when properly applied within its rating.

1.05 SUBMITTALS

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

B. Product Data:
   1. Catalog cut sheets.
   2. Manufacturer’s time-current curves for all molded case circuit breakers furnished.
1.06 QUALITY ASSURANCE
   A. Refer to Section 16050.
   B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING
   A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
   A. Refer to Section 16050.

1.09 WARRANTY
   A. Refer to Section 16050.

1.10 SYSTEM START UP
   A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. One of the following or equal:
      2. General Electric Company.
      3. Square D Company
      4. ABB.

2.02 MANUFACTURED UNITS
   A. General:
      1. Operating mechanism:
         a. Quick-make, quick-break, non-welding silver alloy contacts.
         b. Common Trip, Open and Close for multi-pole breakers such that all poles
            open and close simultaneously.
         c. Mechanically trip free from the handle.
         d. Trip indicating handle - automatically assumes a position midway between
            the manual ON and OFF positions to clearly indicate the circuit breaker
            has tripped.
         e. Lockable in the "OFF" position.
      2. Arc Extinction:
         a. In arc chutes.
      3. Voltage and Current Ratings:
         a. Minimum ratings as indicated on the Drawings.
         b. Minimum frame size 100A.
      4. Interrupting Ratings:
         a. Minimum ratings as indicated on the Drawings.
b. Modify as required to meet requirements of CONTRACTOR’S Short Circuit Fault Analysis - refer to Section 16305.
c. Not less than the rating of the assembly (Panelboard, Switchboard, Motor Control Center, etc.)

B. Motor Circuit Protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.03 COMPONENTS

A. Terminals:
   1. Non-aluminum type steel or copper line and load terminals suitable for the conductor type, size, and number of conductors.
   2. UL listed for Copper or Aluminum conductors.

B. Case:
   1. Molded polyester glass reinforced.
   2. Tamper proof.
   3. Ratings clearly marked.

C. Trip Units:
   1. Instantaneous short circuit protection.
   2. Inverse time delay overload.
   3. Ambient or enclosure compensated by means of a bimetallic element.

D. Molded Case Circuit Breakers For Use In Panelboards:
   1. Bolt-on type.
   2. Plug-in type breakers are not acceptable.
   3. Ground fault trip devices as indicated on the Drawings.

E. Molded Case Circuit Breakers For Use In Switchboards:
   1. “Push-to-Trip” button or a “Twist-to-Trip” adjustment on the breaker front to mechanically simulate an overcurrent trip not operated by the ON-OFF handle.
   2. Provide trip mechanism as indicated on the Drawings:
      a. Thermal magnetic.
      b. Thermal high magnetic.
      c. Solid State:
         1) Adjustable current setting.
         2) Adjustable long time delay.
         3) Adjustable short time pickup.
         4) Adjustable short time delay.
         5) Adjustable instantaneous pickup.
         6) Adjustable ground fault pickup (where shown on the drawings).
         7) Adjustable ground fault delay (where shown on the drawings).
         8) Long time pickup indicator.
   3. Fault Indicators:
      a. Mechanical or powered from a separate battery and charger that is an integral component of the switchboard.
      b. Overload fault trip indication.
      c. Short circuit fault trip indication.
d. Ground fault trip indication (where applicable).

2.04 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
   1. UL 489.
   2. Manufacturer’s standard testing procedures.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16950.

3.03 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the ENGINEER and in accordance with manufacturer’s recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer’s recommendation based on the nameplate values of the installed motor.

3.04 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16422
MOTOR STARTERS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Motor starters and contactors, installed in:
      a. Control Panels.
      b. Enclosed combination starters.
   2. Starter Types:
      a. Magnetic Starters.
      c. Contactors.
      d. Integral Self-Protected Starters.

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

1.02 REFERENCES

A. Refer to Section 16050.

B. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors, and
   Overload Relays Rated 600V.

C. UL508 - Industrial Control Equipment.

D. UL508A - Industrial Control Panels.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions and Abbreviations:
   1. FVNR - Full Voltage Non-reversing.
   2. RVSS - Reduced Voltage Solid State.
   3. Overload Relay Class - A classification on an overload relay time current
      characteristic by means of a number which designates the maximum time in
      seconds at which it will operate when carrying a current equal to 600 percent
      of its current rating.
1.04 SYSTEM DESCRIPTION

A. General Requirements:
   1. Starters for individual enclosed starters, or control panels as indicated on the Drawings or noted in the Specifications.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 16050:
   1. Submit motor starter data with equipment submittal.

B. Product Data:
   1. Manufacturer.
   2. Catalog cutsheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete Bill of Material.
   6. List of recommended spare parts.
   7. Full size, 11 inch by 17 inch, manufacturer original time current curves for:
      a. Overload relays.
      b. Motor circuit protectors.
      c. Thermal magnetic circuit breakers.
      d. Fuses.
   8. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   9. Electrical Ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.

C. Shop Drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.
      b. Indicate wire numbers for all control wires on the diagrams:
         1) Wire numbering in accordance with Section 16075.
      c. Indicate interfaces with other equipment on the drawings.

D. Installation Instructions:
   1. The written instructions must detail the complete installation of the free standing starters including moving and setting into place.
   2. Provide anchorage instructions and requirements for the free standing starter based on the seismic conditions of the site as specified in Section 01612:
      a. Stamped by a Professional Engineer registered in the state where the project is being constructed.

E. Operation and Maintenance Manuals:
   1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
      a. Electrical ratings:
         1) Phase.
2) Wire.
3) Voltage.
4) Ampacity.
b. Complete Bill of Material.
c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
   1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
   2) Pilot devices.
d. Complete renewal parts list.
e. Record Drawings:
   1) Elementary and schematic diagrams.
   2) Provide 1 diagram for every starter and/or contactor.
   3) Indicate wire numbers for all control wires on the drawings:
      a) Wire numbering in accordance with Section 16075.
   4) Indicate interfaces with other equipment on the drawings.
f. 11 inch by 17 inch prints of final record drawings.

F. Certifications:
   1. Provide manufacturer's certification that the reduced voltage solid state starter will reliably control the acceleration and deceleration of the driven load at the installed conditions:
      a. Failure of the manufacturer to provide said certification will be interpreted to mean that the manufacturer has agreed that the reduced voltage solid state starter is matched to the driven load at the installed conditions and will function without fault.
      b. If the reduced voltage solid-state starter fails to perform as desired replace or modify the reduced voltage solid-state starter in order to achieve the desired operational conditions, as directed by the ENGINEER.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Regulatory Requirements:
   1. All starters and components shall be UL listed and labeled:
      a. UL 508 Industrial Control Equipment.
   2. UL 508A - Industrial Control Panels.
   3. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
   4. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.
1.09 SCHEDULING

A. Reduced Voltage Solid State Starters:
   1. Submit certification that the RVSS will reliably accelerate and decelerate the
      driven load at the installed conditions as part of the equipment submittal.
   2. RVSS start-up and testing by manufacturer after connection to equipment.
   3. RVSS training by manufacturer after start-up and testing, and before plant
      commissioning.

1.10 WARRANTY

A. Refer to Section 16050.

1.11 SYSTEM START UP

A. Refer to Section 16050.

B. RVSS:
   1. Provide the services of the manufacturer's technical representative for start-up,
      adjustment, and troubleshooting, a minimum of 2 hours per starter at the
      OWNER'S facility.

1.12 MAINTENANCE

A. Spare Parts:
   1. Provide the following spare parts, suitably packaged and labeled with the
      corresponding equipment number:
      a. One spare fuse of each size and type per starter.
      b. One of each type of circuit board used in the reduced voltage solid state
         starters, including but not limited to:
         1) Control board.
         2) Power board.
         3) Bridge rectifier.
         4) Inverter module.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. NEMA Starters and Contactors:
      a. Allen Bradley.
      b. Square D.
      c. General Electric.
      d. Eaton - Cutler Hammer.
   2. Reduced Voltage Solid State Starters:
      a. Allen Bradley.
      b. Eaton - Cutler Hammer.
      c. General Electric.
      d. Square D.
   3. Manual Motor Starters:
      a. Square D.
b. General Electric.

4. Integral Self-Protected Starters:
   a. Allen Bradley.
   b. Square D - Telemecanique.
   c. General Electric - Surion.
   d. Eaton - Cutler Hammer.

2.02 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-
      magnetic circuit breaker and control power transformer with ratings as
      indicated on the Drawings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum:
         1) With the exception of Integral Self-Protected Starters.
   3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible
      disconnect, and overload trip ratings with nameplate horsepower and current
      ratings of the installed motor:
      a. If motors provided are different in horsepower rating than those specified
         or indicated on the Drawings, provide starters coordinated to the actual
         motors furnished.
   4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking
      contacts.
   5. Mount extended overload reset buttons to be accessible for operation without
      opening starter enclosure door.

B. Full Voltage Starters (FVNR):
   1. Across-the-line full voltage magnetic starters.
   2. Rated for 600 volts.
   3. Electrical characteristics as indicated on the Drawings.
   4. Provide positive, quick-make, quick-break mechanisms, pad lockable
      enclosure doors.
   5. Furnish starter with solid state electronic overload relays.

C. Reduced Voltage Solid State Starters (RVSS):
   1. Provide RVSS starters as a bypass within the Variable Frequency Drives and
      as indicated on the Drawings and in the specifications.
   2. Manufactured and tested in accordance with the applicable requirements of
      IEEE, UL, and NEMA, including the following:
      a. Dielectric withstand per UL 508.
   3. Furnish with a motor circuit protector or thermal magnetic circuit breaker as
      indicated on the Drawings.
   4. Provide protection against internal faults and high SCR temperature during
      operation of the motor including starting, running (except when bypassed), and
      stopping modes.
   5. Capable of continuously delivering full rated current of the motor plus the
      motor service factor in ambient temperatures from 0 degrees Celsius to
      +50 degrees Celsius at the installed altitude.
6. Provide a magnetically operated bypass contactor in parallel with the solid state starter:
   a. The bypass contactor to energize when the motor has reached full speed:
      1) The electronic overload protection circuits must be fully functional with the bypass contactor closed.

7. RVSS control module requirements:
   a. Microcomputer based, and contains the required circuitry to drive the power semiconductors in the power section of the starter.
   b. Integrally mounted on the power section and requires no additional panel space or wiring.
   c. Mounted for easy wiring, testing, service, and replacement.
   d. Provide 3-phase current sensing.
   e. Quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs, and SCR gate firing output circuits.
   f. Operates on power supplied from a control power transformer.
   g. Phase insensitive or with phase rotation protection.
   h. Control modes:
      1) Soft start with adjustable linear ramp time and a “kick start” or “boost” feature to provide a short time (typically 0.1 seconds) application of approximately full voltage.
      2) Soft start with adjustable linear ramp time, with a current limit:
         a) The current limit shall be adjustable over the range of 2 to 4 times normal full load current.
      3) Across the line starting.
      4) Reverse voltage ramp (line voltage to zero voltage):
         a) Adjustable from 2 to 30 seconds to provide smooth stop.
         b) Automatic shutdown at end of voltage ramp.
   i. Protective functions:
      1) Single phase protection.
      2) Under voltage protection.
      3) Short circuit electronic trip overcurrent protection. Time not to exceed 3 cycles.
      4) Inverse time running overcurrent protection.
      5) Auxiliary trip circuitry.
      6) Gate firing circuit lockout protection on trip.
      7) Jam and stall detection.
      8) Fault relay lockout protection.
      9) 100 percent to 130 percent full load running current trip adjustment.
     10) 100 percent to 450 percent of starting current limit adjustment.
     11) Dwell time at current limit with ramp continuation after acceleration.
     12) Individual light emitting diodes (LED’s) for trip and phase loss.
     13) Minimum and maximum initial starting voltage adjustments.
     14) Initial torque adjustment.

8. RVSS power section requirements:
   a. Power section to consist of 3 sets of back-to-back phase controlled power semiconductors:
      1) Minimum repetitive peak inverse voltage of 1500 volts at 480 VAC.
      2) Resistor/capacitor snubber networks to prevent false firing of the SCR’s.
      3) Equipped with individual heat sink assemblies.
      4) Provide high-speed fuses for protection of the SCR stacks against short circuit conditions.
b. Provide metal oxide varistors for transient protection on both the line and load side power terminal connections:
   1) Rated for a minimum of 120 joules.

c. Capable of supplying the following current levels:
   1) 600 percent of full load current for a minimum of 10 seconds.
   2) 450 percent of full load for a minimum of 30 seconds.

d. Furnish ground lugs, one for incoming and one for outgoing ground connections.

e. Furnish pressure type terminals for top or bottom entry power terminations.

9. Remote Indicators:
   a. Provide Form C dry contacts for remote indication of:
      1) Internal fault error.
      2) Undervoltage.
      3) Overvoltage.
      4) Phase reversal.
      5) Phase loss.
      6) Overload.
      7) Frequency out of range.
      8) Excessive starts per hour.
      9) Drive electronics over temperature.
     10) Stall.
     11) Jam.
     12) System failure.
     13) Starter failure.
     14) Run Status.
     15) Full Speed.

10. Metering:
    a. 3 phase motor current.
    b. Power in KW.
    c. Power factor.
    d. Three phase voltage.
    e. Power usage in KWH.

D. Manual Motor Starters:
   1. General:
      a. Provide with number of poles as indicated on the Drawings.
      b. Provide handles that clearly indicate the ON, OFF (with lockout), and TRIPPED positions, pilot light, and positive, quick-make, quick-break mechanisms.

   2. With thermal overload switches:
      a. Provide for all single phase motors 1/3 HP and smaller.
      b. Size heater elements for approximately 115 percent of the nameplate full load current, for motors with a 1.15 service factor.
      c. Thermal overload units in all phase legs:
      d. Overload conditions interrupts all ungrounded conductors.

   3. Without thermal overload switches:
      a. Install only on equipment that requires no external motor overload protection.
      b. Use as disconnect switches at motor when controller is out of sight for motors 10 HP and smaller on 480 Volt, 3-phase systems, as indicated on the Drawings.
4. Enclosure:
   a. Provide the enclosure type specified in Section 16050 for the starter location.

2.03 COMPONENTS

A. Molded Case Circuit Breakers:
   1. Circuit breaker type and ratings as indicated on the Drawings.
   2. Provide in accordance with Section 16412.

B. Contactors:
   1. NEMA size as indicated on the Drawings.
   2. Electrically held:
      a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
   3. Factory adjusted and chatter free.
   4. Auxiliary contacts:
      a. Contact ratings as per NEMA A600 rating:
         1) Auxiliary contacts rated 10 Amps at 600 volts.
      b. Provide all contacts indicated on the Drawings, and any additional contacts required for proper operation.
      c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.

C. Overloads:
   1. Solid State Electronic:
      a. Solid state overload relays:
         1) Conform to the following standards:
            a) UL 508.
            b) IEC 947-4.
            c) IEC 801-1 parts 2 through 6.
         d) Starters incorporating solid state overload relays shall meet the IEC 947-4-1 requirements for Type 2 Coordination at 600VAC with a 100,000 Amp available fault current:
            (1) Type 2 Coordination shall be achieved with NEMA starters when protected by any brand of UL Listed Class RK1, J, or CC fuses.
            (2) Type 2 Coordination shall be achieved with IEC starters when protected by any brand of UL Listed Class J or CC fuses.
         e) IEC starters incorporating solid state overload relays shall meet IEC 947-4-1 requirements for Type 2 Coordination at 415VAC with an 80,000 Amp available fault current when protected by GEC Alsthom Type T fuses.
      b. Selectable Class 10, 20, 30 protection.
      c. Ambient insensitive:
         1) Operating temperature: -20 to 70 degrees Celsius.
      d. Thermal memory.
      e. Protective functions:
         1) Motor overcurrent.
         2) Phase unbalance (adjustable.)
         3) Phase loss.
4) Grand fault protection.
   f. Self-powered.
   g. Provide current transformers for metering of motor current.
   h. Visible trip indicator.
   i. Push-to-trip test.
   j. Isolated normally open alarm and normally closed contact.
   k. Normally closed trip contacts.

2. Solid State Electronic with communications:
   a. Selectable Class 10, 20, 30 protection.
   b. Ambient insensitive:
      1) Operating temperature: -20 to 70 degrees Celsius.
   c. Thermal memory.
   d. Protective functions:
      1) Motor overcurrent.
      2) Phase unbalance (adjustable.)
      3) Phase loss.
      4) Ground fault:
         a) Provide zero sequence current transformer where indicated on the Drawings.
   e. 120 VAC powered.
   f. Provide current transformers for metering of motor current.
   g. Visible trip indicator.
   h. Push-to-trip test.
   i. Isolated normally open alarm contact.
   j. Normally closed trip contacts.
   k. Communications:
      1) DeviceNet.

D. Control Power Transformer:
   1. Furnish integral control power transformer capacity to power:
      a. All motor controls indicated on the Drawings.
      b. Motor winding heaters, through a normally closed auxiliary contact on the starter.
      c. Cabinet heater.
   2. Primary and secondary fusing as indicated on the Drawings:
      a. Fusing sized by the manufacturer for the rating of the transformer furnished.
   3. Control power transformer secondary voltage:
      a. 120VAC.

E. Enclosures for individually enclosed starters:
   1. NEMA type specified for the location in accordance with Section 16050:
      a. Where not indicated, provide NEMA 12 enclosure for indoor dry location, NEMA 4X enclosures for outdoor, wet, or corrosive areas.
   2. Flange-mounted handle mechanism to operate disconnect switch or circuit breaker:
      a. Door mounted operators or operator handles are not acceptable.
      b. Handle mechanism features:
         1) Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
         2) Lockable in the OFF position.
3) Mechanically interlocked so that the disconnect cannot be switched to the ON position with the door open:
   a) Provide a means for qualified personnel to defeat this interlock during maintenance and testing.
4) Lockable in the ON position:
   a) This feature shall not prevent the circuit breaker from operating during a fault condition.
3. Provide a thermostatically controlled space heater for equipment located outdoors or in unheated areas:
   a. Powered from the starter or integral control power transformer.

2.04 ACCESSORIES

A. Lugs and terminals:
   1. For all external connections of No. 6 AWG and larger.
   2. UL listed for either copper or aluminum conductors.
B. Transient voltage surge suppression:
   1. Furnish transient voltage surge protection across the coil of each starter, contactor, and relay.
C. Pilot Devices:
   1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
   2. In accordance with Section 17710.
D. Nameplates:
   1. Provide nameplates in accordance with Section 16075.

2.05 SOURCE QUALITY CONTROL

A. RVSS Starters:
   1. The manufacturer of the respective RVSS starter shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards.
   2. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity, and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
   3. The RVSS starter manufacturer shall test for noise immunity on both input and output power connections and provide test results to the ENGINEER. Noise testing shall be performed in accordance with NEMA ICA 2-230.40.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Starters in Control Panels:
   1. Install in accordance with Section 17710.
C. Install free standing starters per the manufacturer’s guideline and submitted installation instructions to meet the seismic requirements of the project site as defined in Section 01612.

D. Individually Enclosed Starters:
   1. Install the equipment per the manufacturer’s guidelines and submitted installed instruction to meet the seismic requirements at the project site as defined in Section 01612.
   2. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, mounting structures and other accessories needed to completely install the starters.
   3. Assemble and install the starters in the locations and with the layouts indicated on the Drawings.
   4. Perform all work in accordance with the manufacturer’s instructions and accepted shop drawings.
   5. Install floor-standing starters on a 3-1/2 inch raised concrete house keeping pad:
      a. Provide structural leveling channels in accordance with the manufacturer’s recommendations to provide proper alignment of the units.
      b. Weld and/or bolt the starter frame to the leveling channels.
   6. Anchor individually enclosed starters to the wall or housekeeping pad following manufacturer's instructions, and as required by the project seismic requirements.
   7. Provide openings in top or bottom of the enclosure for conduit only, no additional openings will be allowed:
      a. Mis-cut holes will require that the entire enclosure or removable panel be replaced. No hole closers or patches will be allowed.
   8. Bundle circuits together and terminate in each unit:
      a. Tie with nylon wire ties. Refer to Section 16130.
      b. Label all wires at each end with wire numbers shown on the approved control drawings.
      c. Make all connections to and from the motor starter via terminal blocks.
   9. Furnish all mounting brackets, stands, etc. that may be required to physically mount the motor starter.

E. Manual Motor Starters:
   1. Provide complete mounting brackets and hardware as necessary for complete support of manual motor starter at locations indicated on the Drawings.
   2. Mount manual motor starter rigidly to exposed building or equipment structural members.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the Manufacturer, ENGINEER, or testing firm.

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.
3.04 CLEANING

A. Refer to Section 16050.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Demonstrate operation of equipment in accordance with Section 01756:
   1. Demonstrate the operation of every motor starter to the ENGINEER'S and
      OWNER'S satisfaction.

C. Training:
   1. Provide the services of the manufacturer's technical representative for training
      purposes:
      a. RVSS Starters: minimum of 8 hours at the OWNER's facility.

3.06 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16441

GROUP-MOUNTED CIRCUIT BREAKER SWITCHBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Free standing, front access only, dead-front type metal-enclosed distribution, low voltage switchboards, utilizing group mounted circuit protective devices as specified herein, and as shown on the Drawings.

B. Related Sections:
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 16050.

B. American National Standards Institute (ANSI):

C. Institute of Electrical and Electronic Engineers (IEEE).

D. National Electrical Manufacturers' Association (NEMA):
   1. AB-1 - Molded Case Circuit Breakers and Molded Case Switches.
   2. PB-2 - Dead-front Distribution Switchboards.
   3. SG3 - Low Voltage Power Circuit Breakers.

E. Underwriters' Laboratories, Inc. (UL):
   1. UL 50 - Cabinet and Boxes.
   2. UL 891 - Deadfront Switchboards.
   3. UL 489 - Molded Case Circuit Breakers.
   4. UL 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Factory assembled, wired, and tested switchboards, with major components being products of a single manufacturer, including but not limited to, circuit breakers,
instrument, and control transformers, instruments, meters, relays, control devices, and other equipment specified herein and indicated on the Drawings.

B. Description of sections:
1. Utility Metering Compartment:
   a. When shown on the plans furnish an integral Utility current and potential transformer cabinet for Utility Company Metering.
   b. Current transformer bus bars shall be mounted on high impact fiberglass reinforced polyester insulation.
   c. Door with concealed hinges, 3-point catch, and lockable handle.
   d. Metering compartment barriers, rear, top, bottom, and sides.
   e. Current transformer bus bars drilled as per requirements of the electric utility.
   f. Potential transformer connections via drilled and tapped machine screw connections to service entrance bus bars as required by the electric utility.
   g. All dimensions, ratings, spacings, and standards must conform with the requirements of the Electric Utility.
   h. Service Entrance cables to enter the Utility Metering Compartment, in a manner as shown on the plans.
   i. Current and potential transformers shall be configured for hot-sequence metering.
2. Pull Section:
   a. Where indicated on the Drawings provide an incoming line pull section:
      1) Depth equal to that of main device section.
      2) Width based on manufacturer’s standard for the number and size of incoming cables.
      3) Provide a barrier for service entrance applications.
      4) Dimensions cannot exceed those indicated on the Drawings.
3. Space for Future Devices:
   a. Where specified or indicated on the Drawings, space for future devices shall include:
      1) All necessary bus.
      2) Device supports.
      3) Device mounting equipment.
      4) Device connections to bus work.
      5) Wire troughs or raceway space.
      6) Unused device space shall be covered with blank code gauge steel covers or doors.

1.05 SUBMITTALS

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

B. Product Data:
   1. Manufacturer of switchboard.
   2. Manufacturer of all component parts of switchboard.
   3. Weight of switchboard.
   4. Dimensions:
      a. Height.
      b. Length.
      c. Width.
   5. Nameplate schedule.
6. Bill of material.
7. Description of operation:
   a. Metering system.
8. Manufacturer’s time current curves for protective devices printed on 11 inch by 17 inch log-log paper.
9. Ratings:
   a. Voltage.
   b. Phase.
   c. Current.
   d. Interrupting rating (circuit breakers and fuses).
   e. Momentary current rating.
10. List of recommended spare parts.
11. Certification that the Utility Metering Compartment meets the requirements of the serving electrical utility.
12. Name and telephone number of Manufacturer’s authorized parts and repair provider.

C. Shop Drawings:
1. Layout drawings:
   a. Complete, detailed, and scaled switchboard layout:
      1) Front panel.
      2) Sub-panels.
      3) Interior panels.
      4) Top and bottom conduit windows.
2. Complete electrical wiring diagrams:
   a. Point-to-Point connections.
   b. Indicate wire numbers.
3. Complete interface and connection diagrams for metering system.

D. Installation instructions:
1. The written instructions must detail the complete installation of the switchboard including rigging, moving, and setting into place.
2. Provide anchorage instructions and requirements for the switchboard shall be provided based on the seismic conditions of the site as specified in Section 01612:
   a. Stamped by a Professional Engineer registered in the State where the project is being constructed.

E. Operating and Maintenance Manuals:
1. Submit operating instructions and a maintenance manual for the switchboard(s) furnished and/or installed under this contract.
2. Operating instructions:
   a. The written descriptions must detail the operational functions of the switchboard and internal PLC programming if applicable.
3. Maintenance manual:
   a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts.
   b. Manuals to include but are not limited to the following:
      1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
2) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
3) Description of the sequence of operation which outlines the steps which the protective relaying follows during commercial power failure, and fault conditions, and return of commercial power conditions.
4) All schematic, wiring, and external diagrams:
   a) Furnished in a reduced 11 inch by 17-inch fully legible format.

F. Test Reports:
   1. Manufacturer to furnish a certified report after the shop tests.
   2. Manufacturer to furnish a certified report after the start-up:
      a. Report must state that the installation is complete and satisfactory, or list items requiring additional and a proposal for the corrective actions.

G. Certification Letters:
   1. Provide a letter from the Switchboard Manufacturer that lists every paragraph, subparagraph etc. of this specification and states compliance or non-compliance with said paragraph. If non-compliance is indicated provide and explanation for the deviation and alternative method to address the non-compliance.
   2. Provide a letter from the Electric Utility stating that the utility metering compartment meets all serving utility requirement, or provide switchboard shop drawings reviewed, stamped, and signed by the Electric Utility.

H. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the switchboard to prove the switchboard is suitable for the seismic conditions of the site as specified in Section 01612.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Where indicated on the Drawings as service entrance equipment the switchboard shall be U.L. labeled and listed “Suitable for Service Entrance.”

C. Sections and devices shall be UL listed and labeled.

D. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by the ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.07 DELIVERY STORAGE AND HANDLING

A. Refer to Section 16050.

B. Ship the switchboard to the job site on a dedicated air ride vehicle that will allow the CONTRACTOR to utilize onsite off-loading equipment:
   1. Furnish temporary equipment heaters within the switchboard to prevent condensation from forming.
1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.09 SEQUENCING

A. Conduct the initial fault current study in accordance with Section 16305 and submit results for ENGINEER’S review.

B. After successful review of the initial fault current study, submit complete equipment submittal in accordance with Paragraph 1.05 of this specification for ENGINEER’S review.

C. Conduct internal factory test to ensure that systems and equipment are functional and submit Certified Test Results for ENGINEER’S review.

D. Ship equipment to project site after successful completion of Factory Acceptance Test.

E. Assemble equipment in the field.

F. Conduct field acceptance test and submit results for ENGINEER’S review.

G. Submit manufacturer’s certification that equipment has been properly installed and is fully functional for ENGINEER’S review.

H. Conduct OWNER’S Training Sessions.

I. Formally energize, start-up and commission equipment:
   1. Start-up and commissioning shall be performed by the Manufacturer’s authorized representative.

1.10 SCHEDULING

A. Refer to Section 16050.

1.11 WARRANTY

A. Refer to Section 16050.

1.12 SYSTEM START UP

A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton - Cutler-Hammer, "Pow-R-Line C."
   3. Square D. “Power-Style QED.”
B. Circuit Breakers: Same manufacturer as the switchboard.

2.02 EQUIPMENT

A. Switchboard:
   1. Furnish low voltage Class 1 switchboards as specified and indicated on the Drawings.
   2. Provide complete and functional switchboards with respective controls.
   3. Furnish and install devices or accessories not described herein but necessary for the proper installation and operation of the equipment.

B. Voltage Ratings:
   1. Design and construct switchboards to operate on a 480 volt 3-phase, 4-wire 60 hertz solidly grounded system.
   2. Insulation level:
      a. Twice the rated voltage plus 1,000 volts.

C. Bus:
   1. General:
      a. Tin-plated copper.
      b. Bus cross-section per UL heat rise requirements.
      c. Current density of 1,000 amperes per square inch.
      d. Mounted on supports of high-impact, non-tracking insulators.
      e. Phase A-B-C bus arrangement:
         1) Top-to-bottom, left-to-right, front-to-back through out the switchboard.
      f. Symmetrical short circuit current bracing of 100,000 or as indicated on the Drawings.
      g. Continuous current rating as indicated on the Drawings.
   2. Horizontal bus:
      a. Provisions for future connections to additional switchboard sections.
   3. Ground bus:
      a. Sized per UL 891. Rated at 25 percent of incoming capacity.
   4. Neutral bus:
      a. Sized for 50 percent of power bus rating and only located in the Service Entrance section.

D. Enclosure:
   1. General:
      a. Self-supporting structures bolted together to form the required line-up.
      b. All sections rear aligned.
      c. Dead-front.
      d. Conduit entry:
         1) Open-bottom.
         2) Removable top cover.
   2. Frame:
      a. Die-formed 12 gauge steel.
   3. Covers:
      a. Bolt-on.
      b. Code gauge steel.
      c. Removable front covers.
         1) Held in place by captive screws.
4. Rating:
   a. NEMA 1.

2.03 COMPONENTS

A. Circuit Breakers:
   1. General:
      a. Molded case circuit breakers in accordance with Section 16412.
   2. Main Circuit Breaker:
      a. Frame, trip, and short circuit ratings as indicated on the Drawings.
      b. 100 percent rated.
      c. Fixed mounted.
   3. Feeder Breakers:
      a. Frame, trip, and short circuit ratings as indicated on the Drawings.

B. Wiring:
   1. Provide all necessary internal wiring, fuse blocks, and terminal blocks as required.
   2. Number all wires at each end and indicate wire numbers on shop drawings.
   3. Type SIS switchboard wire with at least 26 strands.
   4. Minimum wire size:
      a. No. 14 for control circuits.
      b. No. 12 for potential and current transformer circuits.
   5. Numbered and labeled in accordance with Section 16075.

2.04 ACCESSORIES

A. Metering System:
   1. Include metering as indicated on the Drawings.
   2. Where indicated on the Drawings provide microprocessor based power meters in accordance with Section 16290.

B. Transient Voltage Surge Suppression:
   1. Provide a transient surge protection system as indicated on the Drawings and in conformance with Section 16285.

C. Nameplates:
   1. Provide engraved plastic nameplates to identify:
      a. Switchgear units.
      b. Door mounted components.
      c. Interior mounted devices.
   2. In accordance with Section 16075:
   3. Engraved with the circuit number and circuit name as indicated on the Drawings.
   4. Manufacturers labels:
      a. Each vertical section shall have a label identifying:
         1) Serial number.
         2) Shop order number.
         3) Bus rating.
         4) Vertical section reference number.
         5) Date of manufacture.
D. Warning Signs:
   1. Voltage:
      a. Provide a minimum of two warning signs on the front of the switchgear
         lineup and two on the back.
      b. Red laminated plastic engraved with white letters approximately 1/2 inch
         high.
      c. Signs shall read:
         1) "WARNING-HIGH VOLTAGE-KEEP OUT."
   2. Arc Flash:
      a. Provide one warning sign for each switchboard compartment.
      b. Signs shall have read a minimum of:
         1) “DANGER ELECTRIC ARC FLASH HAZARD.”
         2) Signs shall meet the requirements of NFPA 70E and NEC Article
            110.16.

E. Space Heaters:
   1. Fused, thermostatically controlled, strip-type, operated at half voltage for long
      life:
      a. 500 volt or 250 volt rated heaters at 240 volt or 120 volt respectively.
   2. Space heaters to be powered from the switchboard control power transformer.
   3. Each space heater to be powered through its own dedicated circuit breaker.

F. Lugs:
   1. For all external connections of No. 6 AWG or larger.
   2. U/L listed for copper or aluminum conductors.
   3. Rated for 75 degree Celsius conductors.
   4. Lugs shall be of the compression type in design requiring a hydraulic press
      and die for installation as manufactured by:
      a. Burndy.
      b. T&B.

2.05 FINISHES

A. Chemically clean all steel surfaces before painting.

B. Exterior color ANSI 61 over phosphate-type rust inhibitor.

2.06 SOURCE QUALITY CONTROL

A. Completely assemble, wire and test switchboard at the factory:
   1. Provide groups of wires leaving the shipping-assembled equipment with
      terminal blocks with suitable numbering strips.

B. Manufacturing facility for switchboard shall be registered to the International
   Organization for Standardization ISO 9002 Series Standards for quality.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.
B. Install the switchboard per the manufacturer’s guidelines and submitted installation instructions to meet the seismic requirements at the project site as defined in Section 01612.

C. General:
1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the switchboard.
2. Assemble and install the switchboard in the location and layout indicated on the Drawings
3. Perform work in accordance with manufacturer’s instructions and shop drawings.
4. Furnish components and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install the switchboard on a 3 1/2 inch raised concrete house keeping pad:
   a. Provide structural leveling channels in accordance with the manufacturer’s recommendations to provide proper alignment of the units.
   b. Weld and/or bolt the switchboard frame to be to the leveling channels.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. Manufacturer’s Services:
1. Furnish the services of a factory certified technician during the start-up and adjustment period to ensure that all items furnished are in proper operating condition:
   a. Technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
2. Before start-up, furnish written certification that the entire installation all electrical connections have been inspected and are proper and consistent with all Drawings and Specifications.
3. Furnish a written report after start-up, signed by the technician:
   a. Report must state that the installation is complete and meets all of the manufacturer’s requirements.
   b. List any items requiring additional attention.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

3.04 CLEANING

A. Refer to Section 16050.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Demonstrate the operation to the ENGINEER’s and OWNER’s satisfaction.
C. Training:
   1. Manufacturer shall instruct the OWNER's personnel regarding the operation and maintenance of all items supplied:
      a. Supply written handouts during the training period, and these handouts should be suitable for future reference after the training period is completed.
      b. Training shall consist of one 8-hour session at the OWNER’s facility.
      c. CONTRACTOR to video record the entire training session in DVD format, and deliver the training disk to the OWNER.
      d. Supply complete training documents for 8 individuals:
         1) Training documents to be supplied a minimum of 4 weeks before the training session, and to be used by the OWNER as reference documents during the training period.

3.06 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16445
BRANCH CIRCUIT PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY
A. Section includes requirements for:
   1. Panelboards serving facility branch circuits or other utilization equipment at the following voltage levels:
      a. 208Y/120 Volts, 3-phase, 4-wire.
      b. 120/240 Volts, 1-phase, 3-wire.

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

1.02 REFERENCES
A. Refer to Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

C. Underwriter's Laboratories, Inc. (UL):
   1. UL 67 - Panelboards.
   2. UL 50 - Enclosures for Electrical Equipment.

1.03 DEFINITIONS
A. Refer to Section 16050.

B. Specific Definitions:
   1. Panelboards with the designation LP is used to uniquely identify the individual panelboard, shall comply with requirements of this section.
   2. Lighting and Power panelboards as defined by the NEC.

1.04 SYSTEM DESCRIPTION
A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration per the panel schedules.

1.05 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330 and 16050.
B. Product Data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   3. Manufacturer's time-current curves for protective devices, printed on 11 inch by 17 inch log-log paper.
   4. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   5. NEMA enclosure type.
   6. Catalog sheets for circuit breakers contained within the panelboard.
   7. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.

C. Shop Drawings:
   1. Drawings to contain:
      a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
         1) Height.
         2) Length.
         3) Width.
      b. Weight.
      c. Anchoring locations.
      d. Breaker layout drawing with dimensions:
         1) Location of the main, branches, solid neutral, and ground.
      e. Conduit entry/exit locations.
      f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation Instructions:
   1. Provide anchorage instructions and requirements for the panelboard based on the seismic conditions of the site as specified in Section 01612:
      a. Stamped by a Professional Engineer registered in the State where the project is being constructed.

E. Operations and Maintenance Manual:
   1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
      a. Including but not limited to:
         1) Instruction narratives and bulletins.
         2) Renewal parts lists.
         3) Time-current curves for all devices.

F. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic conditions of the project as specified in Section 01612.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.
B. Panelboards shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
A. Refer to Section 16050.

1.09 WARRANTY
A. Refer to Section 16050.

1.10 SYSTEM START-UP
A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. One of the following or equal:
   2. General Electric Company.

B. Circuit breakers:
   1. Same manufacturer as the panelboard.

2.02 EQUIPMENT
A. Provide panelboards with:
   1. Thermal magnetic molded-case circuit breakers and/or solid-state trip circuit breakers, with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as indicated on the Drawings.

B. Short circuit rating:
   1. Provide panelboards rated 240VAC or 208VAC with a short-circuit ratings as indicated on the Drawings:
      a. Minimum short circuit rating is 22,000 amperes RMS symmetrical.
   2. Provide panelboards rated 480VAC with a short-circuit ratings as indicated on the Drawings:
      a. Minimum short circuit rating is 35,000 amperes RMS symmetrical.
   4. Mark panelboards with their maximum short circuit rating at the supply voltage.
   5. Panelboards shall be fully rated.
2.03 COMPONENTS

A. Enclosure:
   1. NEMA Enclosure Type as indicated on the Drawings.
      a. Where not indicated on the Drawings, provide panelboards with the
         NEMA ratings indicated in Section 16050 for the installed location.
   3. Gutter space in accordance with the National Electric Code:
      a. Minimum of 4 inches of gutter space.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized
      steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder
      tumbler-type lock with catch and door pull.
      a. Minimum two keys per each panelboard.
      b. Key all panelboard locks alike.
   8. Circuit directory frame and card on the inside of the door.
   9. Interior design such that replacement of circuit breakers does not require
      disturbing adjacent units or removal of the main bus connectors.

B. Bus:
   1. General:
      a. Tin-plated copper.
   2. Phase Bus:
      a. Phase busing shall be full size and height without reduction.
      b. Sized in accordance with UL standards to limit temperature rise on any
         current carrying part to a maximum of 50 degrees Celsius:
            1) Limit current density to less than 1,000 Amps per square inch.
      c. Insulate all current carrying parts from ground and phase-to-phase with a
         high dielectric strength insulator.
   3. Ground Bus:
      a. Solidly bonded system copper.
   4. Neutral Bus:
      a. Provide where indicated on the Drawings.
      b. 100-percent rated.
      c. Provide lugs for each outgoing feeder requiring a neutral connection.
   5. Provide insulation barriers over the vertical bus behind the dead front shield to
      provide increased safety during field service.

C. Lugs:
   1. UL listed for copper and aluminum wire:
      a. Provide lugs rated for 75 degree Celsius terminations.
      b. Provide bolted main lug terminations.

D. Circuit Breakers: As specified in Section 16412 and as indicated on the Drawings:
   1. Provide all circuit breakers with bolt-on connections:
      a. Plug-in circuit breakers are not allowed.

2.04 ACCESSORIES

A. Nameplates:
1. In accordance with Section 16075.
2. Install on outside of door.
3. Indicating:
   a. Panel designation.
   b. Voltage.
   c. Number of phases and configuration.
4. Panel Designations in 1/4-inch high letters above voltage and phase in 1/8-inch high letters; for example:

   LPA-1
   208/120V -3PH -4W

B. Circuit Identification Labels:
   1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
   2. Type all information on the cards using designations in the panel schedules.
   3. Laminated on both sides.

2.05 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and two coats of oven-baked enamel with finish color ANSI 61 gray.

B. Finish motor control center mounted panelboards to match the MCC finish and color.

2.06 SOURCE QUALITY CONTROL

A. Perform standard factory tests on the panelboards:
   1. Test in accordance with the latest version of NEMA and UL standards.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Install the equipment per the manufacturer’s guidelines and submitted installed instruction to meet the seismic requirements at the project site as defined in Section 01612.

C. General:
   1. Surface or flush mounted as indicated on the Drawings.
   2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
   3. Perform work in accordance with the manufacturer’s instructions and shop drawings.
   4. Provide all brackets, hangers, supports, and hardware for mounting as required.
   5. Mount panelboard so that top operating handle is not more than 6 feet - 7 inches above the operating floor.
3.02 FIELD QUALITY CONTROL
   A. Refer to Section 16050.

3.03 CLEANING
   A. Refer to Section 16050.

3.04 PROTECTION
   A. Refer to Section 16050.

3.05 SCHEDULES
   A. Circuiting with the panelboard shall match the panel schedules as indicated on the
      Drawings.

   B. Provide type-written schedule in each panelboard.

      END OF SECTION
SECTION 16446

DISTRIBUTION PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   a. Panelboards serving facility feeder circuits or other utilization equipment at the following voltage levels:
      1. 480 Volts, 3 phase, 3 wire.

B. Related Section:
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all Sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

C. Underwriter's Laboratories, Inc. (UL):
   1. UL 67 - Panelboards.
   2. UL 50 - Enclosures for Electrical Equipment.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions:
   1. Panelboards with the designation "DP" is used to uniquely identify the individual panelboard, shall comply with requirements of this section.
   2. Lighting and Power panelboards as defined by the NEC.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration per the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 16050.
B. Product Data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   4. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   5. NEMA enclosure type.
   6. Catalog sheets for circuit breakers contained within the panelboard.
   7. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.

C. Shop Drawings:
   1. Drawings to contain:
      a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
         1) Height.
         2) Length.
         3) Width.
      b. Weight.
      c. Anchoring locations.
      d. Breaker layout drawing with dimensions:
         1) Location of the main, branches, solid neutral, and ground.
      e. Conduit entry/exit locations.
      f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for each and every panelboard.
      g. Where applicable the following additional information shall be submitted to the Engineer:
         1) Key interlock scheme drawing and sequence of operations.

D. Installation Instructions:
   1. Provide anchorage instructions and requirements for the panelboard based on the seismic conditions of the site as specified in Section 01612.
      a. Stamped by a Professional Engineer registered in the State where the project is being constructed.

E. Operations and Maintenance Manual:
   1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
      a. Including but not limited to:
         1) Instruction narratives and bulletins.
         2) Renewal parts lists.
         3) Time-current curves for all devices.

F. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic conditions of the project as specified in Section 01612.
1.06 QUALITY ASSURANCE  
A. Refer to Section 16050.  
B. Panelboards shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING  
A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS  
A. Refer to Section 16050.

1.09 WARRANTY  
A. Refer to Section 16050.

1.10 SYSTEM START-UP  
A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS  
A. One of the following or equal:  
   2. General Electric Company.  
B. Circuit breakers:  
   1. Same manufacturer as the panelboard.

2.02 EQUIPMENT  
A. Provide panelboards with:  
   1. Thermal magnetic molded-case circuit breakers and/or solid-state trip circuit breakers, with trip ratings as shown on the panel schedules.  
   2. Spares and spaces for future circuit breakers in panels as indicated on the Drawings.  
B. Short circuit rating:  
   1. Provide panelboards rated 480VAC with a short-circuit ratings as indicated on the Drawings:  
      a. Minimum short circuit rating is 35,000 amperes RMS symmetrical.  
      2. Testing method per UL 67.  
      3. Mark panelboards with their maximum short circuit rating at the supply voltage.  
      4. Panelboards shall be fully rated.
2.03 COMPONENTS

A. Enclosure:
   1. NEMA Enclosure Type as indicated on the Drawings.
      a. Where not indicated on the Drawings, provide:
         1) NEMA 1 in office areas and electrical rooms.
   3. Gutter space in accordance with the National Electric Code:
      a. Minimum of 4 inches of gutter space.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
      a. Minimum two keys per each panelboard.
      b. Key all panelboard locks alike.
   8. Circuit directory frame and card on the inside of the door.
   9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.

B. Bus:
   1. General:
      a. Tin-plated copper.
   2. Phase Bus:
      a. Phase busing shall be full size and height without reduction.
      b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
         1) Limit current density to less than 1,000 Amps per square inch.
      c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
   3. Ground Bus:
      a. Solidly bonded system copper.
   4. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:
   1. UL listed for copper and aluminum wire:
      a. Provide lugs rated for 75 degree Celsius terminations.
      b. Provide bolted main lug terminations.

D. Circuit Breakers: As specified in Section 16412 and as indicated on the Drawings:
   1. Provide all circuit breakers with bolt-on connections:
      a. Plug-in circuit breakers are not allowed.

2.04 ACCESSORIES

A. Nameplates:
   1. In accordance with Section 16075.
   2. Install on outside of door.
   3. Indicating:
      a. Panel design.
b. Voltage.
c. Number of phases and configuration.
4. Panel Designations in 1/4-inch high letters above voltage and phase in 1/8-inch high letters; for example:

```
PPA-1
480/277V -3PH -4W
```

B. Circuit Identification Labels:
   1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
   2. Type all information on the cards using designations in the panel schedules.
   3. Laminated on both sides.

2.05 FINISHES
A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and two coats of oven-baked enamel with finish color ANSI 61 gray.

2.06 SOURCE QUALITY CONTROL
A. Perform standard factory tests on the panelboards:
   1. Test in accordance with the latest version of NEMA and UL standards.

PART 3 EXECUTION
3.01 INSTALLATION
A. Refer to Section 16050.
B. Install the equipment per the manufacturer’s guidelines and submitted installed instruction to meet the seismic requirements at the project site as defined in Section 01612.
C. General:
   1. Surface or flush mounted as indicated on the Drawings.
   2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
   3. Perform work in accordance with manufacturer’s instructions and shop drawings.
   4. Provide all brackets, hangers, supports, and hardware for mounting as required.
   5. Mount panelboard so that top operating handle is not more than 6 feet - 7 inches above the operating floor.
3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 CLEANING

A. Refer to Section 16050.

3.04 PROTECTION

A. Refer to Section 16050.

3.05 SCHEDULES

A. Circuiting with the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide type-written schedule in each panelboard.

END OF SECTION
SECTION 16494
LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Fuses:
      a. 600-volt class and lower.

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

1.02 REFERENCES

A. Refer to Section 16050.

1.03 DEFINITIONS

A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

A. Fuses for overcurrent protection and/or current limiting applications as indicated on
   the Drawings.

1.05 SUBMITTALS

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

B. Product Data:
   1. Catalog cut sheets.
   2. Complete fuse schedule.
   3. Manufacturer original 11 inch by 17 inch, time current curves for all fuses
      furnished.

C. Shop Drawings:
   1. Include drawings of spare fuse cabinets.

D. Operation and Maintenance Manuals:
   1. Certified factory and field calibration data sheets for instruments and devices
      that require set-up and calibration:
      a. Including factory calibration for each instrument with stated accuracy.
   2. Complete installation, calibration, and testing manuals.
1.06 QUALITY ASSURANCE
   A. Refer to Section 16050.
   B. All low voltage fuses shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
   A. Refer to Section 16050.

1.09 WARRANTY
   A. Refer to Section 16050.

1.10 SYSTEM START UP
   A. Refer to Section 16050.

1.11 MAINTENANCE
   A. Spare parts:
      1. Provide three spare fuses for each size and type used or supplied under any
         Division of these Specifications.
      2. Provide spare fuse cabinet(s):
         a. Metal cabinet with hinged door and shelves or fuse holders.
         b. Gray enamel finish.
         c. Mount near equipment and label "Spare Fuses" on face of cabinet.
         d. Suitable pocket inside door of each cabinet with typewritten spare fuse
            inventory in clear plastic protective insert.
         e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. One of the following:
      1. Ferraz Shawmut.
      2. Littelfuse.

2.02 MANUFACTURED UNITS
   A. General:
      1. Provide durable, readily visible label inside each fuse enclosure, clearly
         indicating the correct type, size, and ratings of replacement fuse:
         a. Label shall not cover or interfere with equipment manufacturer's
            instructions.
2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
3. To assure selective coordination of protective devices:
   a. Provide fuses for new facilities by the same manufacturer.
   b. Provide fuses for renovations of the same manufacturer as existing fuses.
4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

B. Fuses for services, switchboard mains, feeders, and branch circuits:
   1. 600 Amperes and less:
      a. Provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings except as may be modified by these Specifications.

C. Fusing of control circuits:
   1. Provide:
      a. RK1 fuses installed in UL listed Class CC fuse blocks. as specified.
   2. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.
   3. Fuse both the primary and secondary circuit of control power transformers:
      a. Fuse ratings shall be in accordance with NEC requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. General:
   1. Install fuses properly aligned, electrically and mechanically secure.
   2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
   3. Paralleling of fuses is not permitted.
   4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.

C. Replace fuses, on all phases, for any fuses that opened during start-up and testing.

D. After completion of testing, deliver spare fuses in quantities specified:
   1. Fuses shall be new, in manufacturer’s original packaging, and stored in a clean, dry location.

E. Install spare fuse cabinets where instructed by the Owner.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 CLEANING

A. Refer to Section 16050.
3.04 PROTECTION

A. Refer to Section 16050.

END OF SECTION
SECTION 16500
LIGHTING

PART 1  GENERAL

1.01  SUMMARY

A. Section includes requirements for:
   1. Luminaires, lamps, ballasts, and accessories.

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

1.02  REFERENCES

A. Refer to Section 16050.

B. American National Standards Institute (ANSI):
   2. C82.11 - High Frequency Fluorescent Lamp Ballast.
   3. C82.4 – Ballasts for High-Intensity Discharge and Low Pressure Lamp.
   4. C82.77 - Harmonic Emission limits - Related Power Quality Requirements for Lighting Equipment.

C. Underwriters Laboratories (UL):
   1. UL935 - Fluorescent Lamp Ballasts.
   2. UL1029 - High -Intensity Discharge Lamp Ballast.
   3. UL1570 Fluorescent Lighting Fixtures.
   4. UL1572 High Intensity Discharge Lighting Fixtures.

1.03  DEFINITIONS

A. Refer to Section 16050.

B. Specific Definitions and Abbreviations:
   1. BF: Ballast Factor - Measure of light output from lamp operated by commercial ballast as compared to a laboratory standard reference ballast
   2. BEF: Ballast Efficacy Factor - Value used to evaluate various lighting systems based on light output and power input.
   3. CCT: Correlated Color Temperature - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin.
   4. Crest Factor - ratio of peak lamp current to RMS or average lamp operating current.
   5. Efficacy - Lumen output per unit of power supplied to ballast (lumens per watt).
7. FC: Foot Candles - Measure of light level on a surface being illuminated.
8. HID: High Intensity Discharge - A lamp containing a filled arc tube in which the active element becomes vaporized and is discharged into the arc stream to produce light.
9. Instant Start - Lamp starting method in which lamps are started by high voltage input with no preheating of lamp filaments.
10. Luminaire - Lighting unit.
11. Programmed Start - Lamp starting method that utilizes an integrated circuit to preheat the lamp filament while not allowing the lamp to ignite and then applies the open circuit voltage to start the lamp.
12. Pulse Start - An HID ballast with a high voltage igniter that provides high voltage pulses to ionize the gas within the lamp.
13. Rapid Start - Lamp starting method in which lamp filaments are heated while open circuit voltage is applied to facilitate lamp ignition.
14. THD: Total Harmonic Distortion - The combined effect of harmonic Distortion on the AC waveform produced by a ballast or other device.

1.04 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.05 SUBMITTALS

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

B. Product Data:
   1. Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
         4) Gasketing.
         5) Reflector.
         6) Chassis.
         7) Finish and color.
         8) Ballast type and protection.
         9) Lamp:
            a) Type.
            b) Wattage.
            c) Lumen output:
               (1) Initial.
               (2) Mean.
            d) Correlated Color Temperature.
            e) Lamp lumen depreciation.
            f) Efficacy.
            g) Base.
10) Picture of luminaire.
11) Dimensioned Drawings:
   a) Effective Projected Area (EPA) rating for pole mounted luminaires.
12) Weight.
13) Photometric data:
   a) Coefficient of utilization tables based on the IES Zonal Cavity System by an approved testing laboratory.
   b) Luminaire dirt depreciation factor.
   c) Candlepower distribution curves.
   d) Average luminaire brightness.
   e) Lumen output charts.
14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
   a) Support methods shall be based on seismic criteria specified in Section 01612.
2. Luminaire Substitutions:
   1) Provide complete literature for each luminaire substitution:
      a) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
      b) Photometric data:
         (1) IES file in standard IES format.
         (2) Coefficient of utilization tables based on the IES Zonal Cavity System by an approved testing laboratory.
         (3) Candlepower distribution curves.
         (4) Average luminaire brightness.
         (5) Lumen output charts.
   2) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, appearance, and maintenance.
   3) Substitutions shall comply with all applicable building codes.
2. Ballast:
   a. Provide for each ballast type:
      1) Type of ballast.
      2) Lamp wattage.
      3) Input voltage.
      4) Input watts.
      5) Starting line current.
      6) Operating line current.
      7) Sound rating.
      8) Power factor.
      9) Ballast factor.
      10) Starting temperature.
3. Photocell:
   a. Provide for each photocell type:
      1) Switching capacity.
      2) The means of adjusting the lighting pickup level.
      3) Enclosure type.
      4) Mounting method.
C. Calculations:
   1. Provide complete design calculations and installation documents for pole
      mounting piers and poles mounted from structures:
      a. Include in the calculations the project wind design criteria as specified in
         Section 01614, and project seismic design criteria as specified in
         Section 01612.
      b. Calculations and design shall be performed by and signed by a
         Professional Engineer registered in the state where the project is being
         constructed.

D. Record Documents:
   1. Update the Luminaire Schedule in the Drawings to reflect the acceptable
      substitutions, after the substitution has been reviewed and accepted by the
      ENGINEER.

1.06 QUALITY ASSURANCE
   A. Refer to Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. Refer to Section 16050.

1.08 PROJECT OR SITE CONDITIONS
   A. Refer to Section 16050.

1.09 SCHEDULING
   A. Exterior and outdoor lighting system operation shall be demonstrated during the
      hours of darkness.
   B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.10 WARRANTY
   A. Refer to Section 16050.

1.11 SYSTEM START UP
   A. Refer to Section 16050.

1.12 MAINTENANCE
   A. Replace all lamps used during construction and return used lamps to OWNER for
      use as spares.
   B. Furnish five percent of the quantity provided, but not less than three ballasts for
      every ballast type and size used.
   C. Furnish 10 percent of the quantity provided, but not less than 12 new lamps for
      every lamp type and size used.
PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires: One of the following or equal:
   1. As noted on the Luminaire Schedule.

B. Lamps: One of the following or equal:
   2. Osram Sylvania.

C. Ballasts for Fluorescent Lamps: One of the following or equal:
   1. Advance.
   2. Universal.
   3. Osram Sylvania.

D. Ballasts, HID Lamps: One of the following or equal:
   1. Advance.
   2. Holophane.
   3. Osram Sylvania.

E. Substitutions:
   1. CONTRACTOR may make substitutions from the Manufacturers listed in the
      Luminaire Schedule in order to offer a more advantageous luminaire package.
   2. The lighting design and luminaire selection has been based upon the
      photometric data of the identified luminaire. It is the CONTRACTOR’s
      responsibility to ensure and prove to the ENGINEER at time of submittal the
      substitutions meet the quality and photometric requirements of the original
      design.

2.02 EQUIPMENT

A. Luminaires:
   1. General:
      a. Pre-wired with leads of 18-AWG, minimum, for connection to building
         circuits.
      b. Provide the luminaires furnished per the Luminaire Schedule as indicated
         on the Drawings:
         1) The specifications noted herein are an addition or supplement to the
            Luminaire Schedule.
   2. Interior Luminaires:
      a. Interior luminaires shall utilize fluorescent, compact fluorescent, metal
         halide high intensity discharge, or incandescent lamps as indicated on the
         Drawings.
   3. Exterior/Outdoor Luminaires:
      a. Exterior luminaires shall utilize High Pressure Sodium HID or Metal Halide
         HID lamps as indicated on the Drawings, unless otherwise noted.
      b. Luminaires in combination with their mounting pole and bracket shall be
         capable of withstanding:
1) Winds levels consistent with the levels identified in Section 01614 without damage.
2) Seismic levels in accordance with Section 01612.
c. Corrosion-resistant hardware and hinged doors or lens retainer.
d. Luminares furnished with integral photoelectrical control shall be of the luminaire Manufacturer's standard design.

B. Lamps:
1. General:
   a. Provide lamps as indicated on the Luminaire Schedule.
   b. Lamps selected to mate with luminares selected.
   c. Suitable for operation in any burning position unless otherwise indicated in the Contract Documents.
2. Fluorescent lamps:
   a. Type T8 unless otherwise indicated on the Luminaire Schedule.
3. Compact Fluorescent lamps:
   a. 4-pin biax lamps unless otherwise indicated on the Luminaire Schedule.
4. Incandescent lamps:
   a. Frosted interior envelope, unless a specified lighting control system requires clear globe lamps.
   b. Rated 130 Volts AC.
   c. Lamp shape standard A or PS unless otherwise noted.
   d. Lamps to utilize filaments recognized by dimming system Manufacturer to reduce “ringing” and “chatter” of the lamp.
5. High Intensity Discharge Lamps:
   a. Metal Halide Lamps:
      1) Pulse Start.
   b. High Pressure Sodium Lamps:
      1) Color corrected.

C. Photo-Electric Cells:
1. Photoelectric cells for control of multiple luminaires:
   a. Self-contained.
   b. Weatherproof.
   c. Provided with time-delay features.
2. Photoelectric cell for control of a single luminaire:
   a. Integral to the luminaire.

D. Luminaire Control:
1. Lighting control relays or contactors shall conform to the requirements of Section 16422.

E. Ballasts:
1. General:
   a. Energy saving type suitable for use with energy saving lamps where available.
   b. Suitable for operation over the entire temperature range specified in Section 16050 for all luminaires not located in office areas or air conditioned spaces.
2. Ballasts for Fluorescent Lamps:
   a. Operate as a parallel circuit allowing remaining lamp(s) to maintain full light output if one or more lamps fail.
   b. Bear CBM and ETL labels.
   c. High frequency electronic type:
      1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
   d. High output application:
      1) Utilize instant-start ballast.
   e. Total Harmonic Distortion (THD) of the input current less than 20 percent.
   f. Sound rating: Class A or quieter.
   g. UL Class P, Type 1 thermally protected, or individually fused in accordance with manufacturer's recommendations.
   h. Auto restart circuitry to restart lamps without resetting power.
   i. Input power source:
      1) 120 VAC 60 Hz or indicated on the Drawings.
      2) Use universal voltage ballasts when available.
      3) With sustained variations of ± 10 percent (voltage and frequency) with no change to the ballast.
   j. Power factor:
      1) Greater than 0.98 for primary lamp.
      2) Greater than 0.90 throughout the dimming range if applicable.
   k. Ballast factor:
      1) Low energy: 0.70 minimum.
      2) Instant start: 0.90 minimum.
      3) High output: 1.20 minimum.
   l. Lamp current crest factor:
      1) 1.7 or less for lamps operating in accordance with ANSI C82.1 parameters.
   m. Minimum starting temperature:
      1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or noted in Section 16050:
         a) For standard T8 lamps: -29 degrees Celsius (-20 degrees Fahrenheit).
         b) For T8/HO, and Slimline T12 lamps: 10 degrees Celsius (50 degrees Fahrenheit).
         c) For Slimline T8 lamps: 0 degrees Celsius (32 degrees Fahrenheit).
         d) For T12/HO lamps: -29 degrees Celsius (-20 degrees Fahrenheit).
         e) For energy saving T8 and T12 lamps: 16 degrees Celsius (60 degrees Fahrenheit).
   n. Tolerate sustained open circuit and short circuit output conditions without damage.
   o. High efficiency and meet all US state and federal efficacy laws.
   p. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
   q. Rated for location of installation.
3. Ballast for Compact Fluorescent Lamps:
a. Type:
   1) Programmed start.
   2) Incorporate lamp shutdown circuitry for end of lamp life protection.
b. High frequency electronic type:
   1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
c. Input power source:
   1) 120 VAC, 60 Hz or as indicated on the Drawings.
   2) With sustained variations of ± 10 percent (voltage and frequency) with no damage to the ballast.
d. Lamp current crest factor:
   1) 1.7 or less for lamps operating in accordance with ANSI C82.1 parameters.
e. UL Class P, Type 1 thermally protected, or be individually fused in accordance with manufacturer's recommendations.
f. Power factor:
   1) Greater than 0.98 for primary lamp.
   2) Greater than 0.90 throughout the dimming range for primary lamp.
g. Ballast factor: 1.0 at maximum light output.
h. Minimum starting temperature:
   1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or noted in Section 16050:
      a) For compact fluorescent lamps: 10 degrees Celsius (50 degrees Fahrenheit).
i. Sound rating: Class A or quieter.
j. Total Harmonic Distortion (THD) of the input current less than 10 percent.
k. Tolerate sustained open circuit and short circuit output conditions without damage.
l. High efficiency and meet all US state and federal efficacy laws.
m. Rated for location of installation.

4. Ballasts for High Intensity Discharge Lamps:
   a. Meet requirements of UL 1029.
   b. Input power source:
      1) As indicated on the Drawings.
   c. With sustained variations of ± 10 percent (voltage and frequency) with no change to the ballast.
   d. Minimum starting temperature:
      1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or noted in Section 16050.
      a) High Pressure Sodium: -40 degrees Celsius.
      b) Metal Halide lamps: -30 degrees Celsius.
   e. Power factor: greater than 0.90.
   f. Provide pulse start for metal halide.
   g. Core and coil ballast with class “H” (180 degree Celsius) or higher insulation system and vacuum-pressure impregnated with silica-filled polyester resin:
      1) Copper windings.
      2) Internally fused.
   h. Ballast factor: 1.0.
PART 3  EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050.

B. Install luminaires per the Manufacturer’s guidelines and submitted installation calculations to meet seismic and wind withstand ratings in accordance with Sections 01612 and 01614.

C. Special Techniques:
   1. Luminaires shall be installed plumb and square with building and wall intersections:
      a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
      b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or duct work.
   2. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
      a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
   3. Install luminaires in accordance with the architectural reflected ceiling Drawings:
      a. Center luminaires on ceiling tiles unless otherwise indicated.
   4. Luminaires weighing more than 25 pounds shall be supported independently of the outlet box and the conduit.
   5. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
      a. The safety supports shall consist of #12 AWG soft drawn galvanized wires.
   6. Support luminaires installed in suspended grid ceilings, independently of the grid:
      a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

3.03 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by the Owner’s Representative or the ENGINEER.

3.04 CLEANING

A. Refer to Section 16050.

B. Clean all lenses, diffusers, and reflectors.

C. Refinish all luminaire’s trim and support brackets, where finish has been damaged.
D. Clean and re-lamp all luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Perform the lighting demonstration, in accordance with paragraph 1.10 of this Section, witnessed by the OWNER’s Representative and the ENGINEER:
   1. The entire lighting system shall be observed to verify:
      a. Luminaires are properly focused and aimed.
      b. Switching functions are in accordance with the Contract Documents and verify all:
         1) Photocell operation.

3.06 PROTECTION

A. Refer to Section 16050.

3.07 SCHEDULES

A. Refer to the Luminaire Schedules as indicated on the Drawings.

END OF SECTION
SECTION 16950
FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Responsibilities for testing the electrical installation.
   2. Routine tests during installation.
   3. Adjusting and calibration.
   4. Acceptance tests.
   5. Demonstration of electrical equipment.
   6. Commissioning and plant startup.

B. Related Sections:
   1. The Contract Documents: are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all Sections to ensure a complete and coordinated project.

C. Copyright information:
   1. Some portions of this section are copyrighted by the International Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. Refer to Section 16050.

B. International Electrical Testing Association Incorporated:

C. Manufacturer’s testing recommendations and instruction manuals.

D. Specification sections for the electrical equipment being tested.

E. Shop drawings.

1.03 DEFINITIONS

A. Refer to Section 16050.

B. Definitions of terms and other electrical considerations as set forth in the:

C. Specific definitions:
   1. Testing Laboratory: The organization performing acceptance tests.
1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this contract in accordance with the manufacturer’s requirements and as specified herein.

B. Conduct all tests in the presence of the ENGINEER or the Engineer’s representative:
   1. The ENGINEER will witness all visual, mechanical and electrical tests, and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these specifications. The results of the tests shall determine the suitability for continued reliable operation.

D. Responsibilities:
   1. CONTRACTOR responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical Subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, CONTRACTOR, and other Subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.
         5) Replacing blown fuses.
         6) Installing temporary jumpers.
   3. Testing laboratory responsibilities:
      a. Perform all acceptance tests as defined herein.
      b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices:
   1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

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

B. Test Report:
   1. Include the following:
      a. Summary of project.
      b. Description of equipment tested.
      c. Description of tests performed.
      d. Test results.
      e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.

C. Testing Laboratory qualifications:
   1. Submit a complete resume and statement of qualifications from the proposed
testing laboratory detailing their experience in performing the tests specified:
      a. This statement will be used to determine whether the laboratory is
         acceptable, and shall include:
         1) Corporate history and references.
         2) Resume of individual performing test.
         3) Equipment list and test calibration data.

D. Division of responsibilities:
   1. Submit a list identifying who is responsible for performing each portion of the
      testing.

E. Manufacturers testing procedures:
   1. Submit manufacturers recommended testing procedures and acceptable test
      results for review by the ENGINEER.

1.06 QUALITY ASSURANCE

A. Refer to Section 16050.

B. Testing Laboratory qualifications:
   1. The Testing Laboratory may be qualified testing personnel from the electrical
      subcontractor’s staff or an independent testing company.
   2. Selection of the Testing Laboratory and testing personnel is subject to
      approval by the ENGINEER based on testing experience and certifications of
      the individuals and testing capabilities of the organization.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.08 SEQUENCING

A. Perform testing in the following sequence:
   1. Perform routine tests as the equipment is installed including:
      a. Insulation resistance tests.
      b. Continuity tests.
      c. Rotational tests.
   2. Adjusting and preliminary calibration.
   3. Acceptance tests.
   4. Demonstration.
   5. Commissioning and plant startup.

1.09 WARRANTY

A. Refer to Section 16050.
1.10 COMMISSIONING

A. Commissioning and plant startup, as described in the Specifications, shall not begin until acceptance testing is complete, and operation has been demonstrated to the satisfaction of the ENGINEER.

B. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable:
   1. Simulation of process parameters will be considered only upon receipt of a written request by the CONTRACTOR.

C. Record all motor currents during normal operation.

D. Record the indications of all power meters every half-hour during commissioning.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. General:
   1. Test instrument calibration:
      a. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
      b. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.
      c. Calibrate instruments in accordance with the following frequency schedule:
         1) Field instruments - 6 months maximum.
         2) Laboratory instruments - 12 months maximum.
         3) Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble) - 12 months maximum.
      d. Dated calibration labels shall be visible on all test equipment.
      e. Maintain an up-to-date instrument calibration record for each test instrument:
         1) The records shall show the date and results of each calibration or test.
      f. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

PART 3 EXECUTION

3.01 PREPARATION

A. Do not begin testing until the following conditions have been met:
   1. All instruments required are available and in proper operating condition.
   2. All required dispensable materials such as solvents, rags, and brushes are available.
   3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.02 FIELD QUALITY CONTROL

A. Switchboard:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with the Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding and required area clearances.
      d. Inspect equipment for cleanliness.
      e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
      f. Verify that current and voltage transformer ratios correspond to the Drawings.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      h. Mechanical and electrical interlocks:
         1) Attempt closure on locked-open devices.
         2) Attempt to open locked-closed devices.
      i. Lubrication requirements:
         1) Verify appropriate lubrication on moving current-carrying parts.
         2) Verify appropriate lubrication on moving and sliding surfaces.
      j. Inspect insulators for evidence of physical damage or contaminated surfaces.
      k. Verify correct barrier and shutter installation and operation.
      l. Exercise all active components.
      m. Inspect all indicating devices for correct operation.
      n. Verify that filters are in place and/or vents are clear.
      o. Perform visual and mechanical inspection of instrument transformers as specified herein.
      p. Inspect control power transformers:
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
         3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.
      b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.
         1) Perform test in accordance with NETA ATS tables.
c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer’s published data or NETA ATS tables. Apply the test voltage for one minute.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Apply the test voltage for 1 minute:
   1) For solid state devices that can not tolerate the applied voltage, follow the manufacturer’s recommendation.

e. Perform electrical tests on instrument transformers as specified herein.

f. Perform ground-resistance tests:
   1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.

g. Determine the accuracy of all meters.

h. Control power transformers:
   1) Perform insulation resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:
      a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
   2) Perform secondary wiring integrity test:
      a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
         1) Verify correct potential at all devices.
      3) Verify correct secondary voltage by energizing primary winding with system voltage:
         a) Measure secondary voltage with the secondary wiring disconnected.

i. Voltage transformers:
   1) Perform secondary wiring integrity test:
      a) Verify correct potential at all devices.
   2) Verify correct secondary voltage by energizing primary winding with system voltage.

j. Perform current injection tests on the entire current circuit of each switchboard:
   1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
      a) Verify the correct magnitude of current at each device in the circuit.
   2) Perform current tests by primary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
      a) Verify the correct magnitude of current at each device in the circuit.

k. Perform system function tests.

l. Verify operation of space heaters.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
1) Refer to NETA ATS tables in the absence of manufacturer’s published data.

c. Compare bus connection resistances to values of similar connections.
   1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   2) Insulation-resistance values of bus insulation shall be in accordance with manufacturer’s published data:
      a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      b) Investigate insulation values less than the allowable minimum.
      c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

d. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

e. Insulation-resistance values for control wiring shall not be less than two megohms.

f. Instrument transformer test values as specified herein.

g. Investigate grounding system resistance values that exceed 0.5 ohm.

h. Meter accuracy shall be in accordance with manufacturer’s published data.

i. Control Power Transformers:
   1) Insulation resistance values of control power transformers shall be in accordance with manufacturer’s published data:
      a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      b) Investigate insulation values less than the allowable minimum.
      c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
   2) Secondary wiring shall be in accordance with the Drawings and Specifications.
   3) Secondary voltage shall be in accordance with the Drawings.

j. Voltage Transformers:
   1) Secondary wiring shall be in accordance with the Drawings and Specifications.
   2) Secondary voltage shall be in accordance with the Drawings.

k. Current-injection tests shall prove current wiring is in accordance with the Drawings and Specifications.

l. Results of system function tests shall match the Drawings and Specifications.

m. Heaters shall be operational.

n. Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the Drawings and Specifications.

B. Dry Type Transformers:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with the Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify that resilient mounts are free and that any shipping brackets have been removed.
e. Inspect equipment for cleanliness.
f. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
      a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
g. Verify that as-left tap connections are as specified.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
      1) Apply voltage in accordance with manufacturer’s published data.
         a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Calculate dielectric absorption ration or polarization index.
   d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Tap connections are left as found unless otherwise specified.
   d. Minimum insulation resistance values of transformer insulation shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      2) Investigate insulation values less then the allowable minimum.
   e. The dielectric absorption ratio or polarization index shall not be less than 1.0.
   f. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

C. Cables, 600 volts and less:
   1. Visual and Mechanical Inspection:
      a. Compare cable data with the Drawings and Specifications.
      b. Inspect exposed sections of cables for physical damage and correct connection in accordance with the Drawings.
      c. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect compression-applied connectors for correct cable match and indentation.
e. Inspect for correct identification and arrangements.
f. Inspect jacket insulation and condition.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
   b. Perform insulation-resistance tests on each conductor with respect to ground and adjacent conductors:
      1) Applied voltage shall be:
         a) 500 volts dc for 300 volt rated cable.
         b) 1000 volts dc for 600 volt rated cable.
      2) Test duration shall be one minute.
   c. Perform continuity tests to ensure correct cable connection.
   d. Verify uniform resistance of parallel conductors.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Insulation resistance values shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      2) Investigate values of insulation resistance less than the allowable minimum.
   d. Cables shall exhibit continuity.
   e. Investigate deviations in resistance between parallel conductors.

D. Low Voltage Molded Case Circuit Breakers:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage and alignment.
      d. Verify the unit is clean.
      e. Operate circuit breaker to ensure smooth operation.
      f. Inspect bolted electrical connections for high resistance by one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
      h. Perform adjustments for final protective device settings in accordance with the coordination study.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
      1) Apply voltage in accordance with manufacturer’s published data.
      2) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Perform a contact/pole-resistance test.
   d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Apply the test voltage for 1 minute:
      1) For solid state devices that can not tolerate the applied voltage, follow the manufacturer’s recommendation.
   e. Determine long-time pickup and delay by primary current injection.
   f. Determine short-time pickup and delay by primary current injection.
   g. Determine ground-fault pickup and delay by primary current injection.
   h. Determine instantaneous pickup value by primary current injection.
   i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data.
   j. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition:
      1) Reset all trip logs and indicators.
   k. Verify operation of charging mechanism.
3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Insulation resistance values shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      2) Investigate values of insulation resistance less than the allowable minimum.
   d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data:
      1) If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   e. Insulation resistance values of control wiring shall not be less than two megohms.
   f. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current characteristic tolerance band including adjustment factors:
1) If manufacturer’s curves and are not available, trip times shall not exceed the value shown in NETA ATS tables.

g. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.

h. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.

i. Instantaneous pickup values shall be as specified and within manufacturer’s published tolerances:
   1) Refer to NETA ATS tables in the absence of manufacturer’s published data.

j. Pickup values and trip characteristics shall be within manufacturer’s published tolerances.

k. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.

l. The charging mechanism shall operate in accordance with manufacturer’s published data.

E. Instrument Transformers:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with the Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Verify correct connection of transformers with system requirements.
      d. Verify that adequate clearances exist between primary and secondary circuit wiring.
      e. Verify the unit is clean.
      f. Verify that all required grounding and shorting connections provide contact.
      g. Verify correct operation of transformer withdrawal mechanism and grounding operation.
      h. Verify correct primary and secondary fuse sizes for voltage transformers.
      i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

   2. Electrical Tests - Current Transformers:
      a. Perform a ratio verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1.
      b. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3:
         1) That grounding point should be located as specified by the ENGINEER in the Contract Documents.

   3. Electrical Tests - Voltage Transformers:
      a. Perform a polarity test on each voltage transformer to verify the polarity marks on H1- X1 relationship as applicable.
      b. Perform a turns ratio test on all tap positions.
      c. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3:
         1) That grounding point should be located as specified by the ENGINEER in the Contract Documents.

   4. Test Values:
      a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
   1) Refer to NETA ATS tables in the absence of manufacturer’s published data.

c. Test results shall indicate that the circuits have only one grounding point.

F. Metering Devices:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      d. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.
      e. Verify the unit is clean.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Verify accuracy of meter at all cardinal points.
      c. Calibrate meters in accordance with manufacturer’s published data.
      d. Verify all instrument multipliers.
      e. Verify that current transformer, and voltage transformer secondary circuits are intact.
   3. Test Values:
      a. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
         1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      c. Meter accuracy shall be in accordance with manufacturer’s published data.
      d. Calibration results shall be within manufacturer’s published tolerances.
      e. Instrument multipliers shall be in accordance with system design specifications.
      f. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

G. Grounding Systems:
   1. Visual and mechanical inspection:
      a. Inspect ground system for compliance with the Drawings, Specifications, and the National Electrical Code.
      b. Inspect physical and mechanical condition.
c. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
      a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.

d. Inspect anchorage.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform fall of potential test or alternative test in accordance with ANSI/IEEE Standard 81 on the main grounding electrode or system.
   c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.

3. Test values:
   a. Grounding system electrical and mechanical connections shall be free of corrosion.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   d. The resistance between the main grounding electrode and ground shall be no greater than 5 ohms for commercial or industrial systems and 1 ohm or less for generating or transmission station grounds unless otherwise specified by the ENGINEER.
   e. Investigate point-to-point resistance values that exceed 0.5 ohm.

H. Rotating Machinery:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate information with the Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Inspect air baffles, filter media, cooling fans.
      e. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      f. Perform special tests such as gap spacing and machine alignment if applicable.
      g. Verify correct application of appropriate lubrication and lubrication systems.
2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance test in accordance with ANSI/IEEE 43:
      1) On motors 200 HP and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
      2) On motors larger than 200 HP, test duration shall be 10 minutes. Calculate polarization index.
   c. Perform dc dielectric withstand voltage tests on machines rated at 2300 volts and greater in accordance with ANSI/IEEE Standard 95.
   d. Perform phase-to-phase stator resistance test on machines rated at 2300 volts and greater.
   e. Perform insulation resistance test on insulated bearings in accordance with manufacturer’s published data.
   f. Test motor starter as specified herein.
   g. Verify operation of motor space heater.
   h. Perform vibration test.
   i. Perform a rotation test to ensure correct shaft rotation.
   j. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.

3. Test Values:
   a. Inspection:
      1) Air baffles shall be clean and installed in accordance with the manufacturer’s published data.
      2) Filter media shall be clean and installed in accordance with the manufacturer’s published data.
      3) Cooling fans shall operate.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   d. Air-gap spacing and machine alignment shall be in accordance with manufacturer’s published data.
   e. The dielectric absorption ratio or polarization index shall not be less that 1.0. The recommended minimum insulation (IR$_{2}$ min) test results in meghoms shall be corrected to 40 degrees Celsius and read as follows:
      1) IR$_{2}$ min = KV + 1 for most windings made before 1970, all field windings, and others not described below. (KV is the rated machine terminal-to-terminal voltage in rms kV)
      2) IR$_{2}$ min = 100 meghoms for most dc armature and ac windings built after 1970 (form-wound coils)
      3) IR$_{2}$ min = 5 meghoms for most machines and random-wound stator coils and form-wound coils rated below 1 kV.
      Note: Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.
   f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
g. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.

h. Power factor or dissipation factor values shall be compared to manufacturer’s published data:
   1) In the absence of manufacturer’s published data compare values of similar machines.

i. Tip-up values shall indicate no significant increase in power factor.

j. If no evidence of distress, insulation failure or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.

k. Bearing insulation resistance measurements shall be within manufacturer’s published tolerances:
   1) In the absence of manufacturer’s published data compare values of similar machines.

l. Test results of surge protection devices shall be as specified herein.

m. Test results of motor starter equipment shall be as specified herein.

n. Heaters shall be operational.

o. Vibration amplitudes shall not exceed values in NETA ATS tables:
   1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

p. Machine rotation should match required rotation of connected load.

q. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

I. Motor Starters, Low Voltage:
   1. Visual and Mechanical Inspection:
      a. Compare equipment nameplate information with the Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify the unit is clean.
      e. Inspect contactors:
         1) Verify mechanical operation.
         2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer’s published data.
      f. Motor-running protection:
         1) Verify overload element rating is correct for its application.
         2) If motor running protection is provided by fuses, verify correct fuse rating.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      h. Lubrication requirements:
         1) Verify appropriate lubrication on moving current-carrying parts.
         2) Verify appropriate lubrication on moving and sliding surfaces.
   2. Electrical Tests:
a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
b. Perform insulation resistance tests for one minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for one minute:
   1) Test voltage shall be in accordance with manufacturer’s published data.
   2) Refer to NETA ATS tables in the absence of manufacturer’s published data.
c. Test motor protection devices in accordance with manufacturer’s published data.
d. Test circuit breakers as specified herein.
e. Perform operational tests by initiating control devices.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Insulation resistance values shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      2) Investigate values of insulation resistance less than the allowable minimum.
   d. Insulation resistance values of control wiring shall not be less than two megohms.
   e. Motor protection parameters shall be in accordance with manufacturer’s published data.
   f. Circuit breaker test results shall as specified herein.
   g. Control devices shall perform in accordance with system design requirements.

J. Variable Frequency Drive Systems:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify the unit is clean.
      e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
      f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
      g. Motor running protection:
         1) Verify drive overcurrent setpoints are correct for their application.
         2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
         3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
h. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
      a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.

i. Verify correct fuse sizing in accordance with manufacturer’s published data.

j. Perform visual and mechanical inspection of input circuit breaker as specified herein.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
   b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
   c. Test for the following parameters in accordance with relay calibration procedures specified herein or as recommended by the manufacturer:
      1) Input phase loss protection.
      2) Input overvoltage protection.
      3) Output phase rotation.
      4) Overtemperature protection.
      5) DC overvoltage protection.
      6) Overfrequency protection.
      7) Drive overload protection.
      8) Fault alarm outputs.
   d. Perform continuity tests on bonding conductors as specified herein.
   e. Perform startup of drive in accordance with manufacturer’s published data. Calibrate drive to the system’s minimum and maximum speed control signals.
   f. Perform operational tests by initiating control devices:
      1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
      2) Verify operation of drive from remote start/stop and speed control signals.
   g. Perform electrical tests of input circuit breaker as specified herein.

3. Test Values:
   a. Compare bolted connection resistances to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer’s published time-current curve.
   d. Test values for input circuit breaker shall be as specified herein.
   e. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
   f. Relay calibration results shall be as specified herein.
   g. Continuity of bonding conductors shall be as specified herein.
h. Control devices shall perform in accordance with system requirements.
i. Operational tests shall conform to system design requirements.

3.03 ADJUSTING

A. Adjust limit switches and level switches to their operating points before testing.

B. Set pressure switches, flow switches, and timing relays to anticipated values before testing:
   1. Final settings shall be as dictated by operating results during testing.

3.04 CLEANING

A. Refer to Section 16050.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 16050.

B. Subsystem Demonstration:
   1. Subsystem, as used in this Section, means individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, lighting control systems and other electrically operated or controlled equipment.
   2. Before demonstrating any subsystem:
      a. Demonstrate proper operation of all alarm and status contacts.
      b. Adjust and calibrate all process and control devices as accurately as possible.
   3. Operate each subsystem in its manual mode:
      a. Demonstrate compliance with all Contract requirements.
   4. After each subsystem has operated successfully in its manual mode, perform automatic and remote operation demonstrations:
      a. Verify that all features are fully operational and meet all Contract requirements.
      b. Demonstrate all operating modes and sequences, including proper start and stop sequence of pumps, proper operation of valves and proper speed control.

3.06 PROTECTION

A. Refer to Section 16050.

3.07 SCHEDULES

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer’s complete field testing procedures to the ENGINEER and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

END OF SECTION
SECTION 16990

SAMPLE TYPICAL DRAWINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Sample drawings for the understanding of minimum format and information on required submittals of schematic, interconnection wiring diagrams, and loop drawings.

B. Related Sections:
   1. Section 16050

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
ITEM C – SAMPLE OF TYPICAL STARTER WIRING DIAGRAM

SLUDGE TRANSFER PUMP No.____

SEE EQUIPMENT INTERCONNECTION WIRING DIAGRAM
* ALL WIRE NUMBERS SHALL BE PREFIXED BY THE EQUIPMENT CIRCUIT NUMBER.

CLIENT: ___________________________ AS BUILT DWG
PROJECT: ___________________________ CONTRACTOR: ________________

CONFORMED – May 2012
16990-4
6918B11

pw://Carollo/Documents/Client/CA/Turlock/6918B11/Specifications/16990 (Conformed)
PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
1. General requirements applicable to all process control and instrumentation work.
2. General requirements for process control and instrumentation submittals.

B. Related sections:
1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01140 - Work Restrictions.
   b. Section 01292 - Schedule of Values.
   c. Section 01312 - Project Meetings.
   d. Section 01324 - Progress Schedules and Reports.
   e. Section 01329 - Safety Plan.
   f. Section 01330 - Submittal Procedures.
   g. Section 01410 - Regulatory Requirements.
   h. Section 01450 - Quality Control.
   i. Section 01610 - Project Design Criteria.
   j. Section 01612 - Seismic Design Criteria.
   k. Section 01614 - Wind Design Criteria.
   m. Section 01770 - Closeout Procedures.
   n. Section 01782 - Electronic Operation and Maintenance Manuals.
   o. Section 16050 - General Requirements for Electrical Work.
   p. Section 16075 - Electrical Identification.
   q. Section 17051 - Prequalification of Instrumentation and Control System Contractor.
   r. Section 17100 - Control Strategies.
   s. Section 17761 - PLC Programming Software.
   t. Section 17762 - Control Systems SCADA Software.
   u. Section 17950 - Testing, Calibration, and Commissioning.

C. Interfaces to Equipment, Instruments, and Other Components:
1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a
minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.

2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
   a. Make all changes necessary to meet the manufacturer’s wiring requirements.

3. Submit all such changes and additions to the ENGINEER for acceptance in accordance with the General Conditions.

4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items that appear on Drawings or in Specifications from another discipline in the scope of Work:
   a. If a conflict between Drawings and Specifications is discovered, refer conflict to the ENGINEER as soon as possible for resolution.

5. Loop Drawings:
   a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
   b. The minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.

D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements of Division 17, whether referenced in the individual equipment specifications or not:
   1. The requirements of Division 17 apply to all instrumentation and control work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of Division 17.
   3. The OWNER is not responsible for any additional costs due to the failure of the CONTRACTOR to notify all subcontractors and suppliers of the Division 17 requirements.

E. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The instrumentation and control drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the instrumentation work. Follow the Drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the
best possible installation, use the entire Drawing set for construction purposes.

b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the work to ensure the best possible installation:

1) The equipment locations and dimensions shown on plans and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.

2) The CONTRACTOR has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the ENGINEER has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer’s equipment fits in the allotted space. It is the CONTRACTOR’s responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation Details:

1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the ENGINEER.

d. Schematic Diagrams:

1) All controls are shown de-energized.

2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.

4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences found in the Drawings or Specifications. Combine all information and furnish a coordinated and fully functional control system.

F. Alternates/Alternatives:

1. Refer to the General Conditions for substitute item provisions.

G. Changes and Change Orders:

1. Refer to the General Conditions.

H. Products Installed But Not Supplied Under This Section:

1. HSQ RTU and RTU enclosure will be purchased by the OWNER and shall be installed by the CONTRACTOR.
1. HSQ RTU will be purchased by the OWNER. The CONTRACTOR shall provide the RTU enclosure. The OWNER will install the HSQ RTU in the enclosure.

2. Conduit from RTU enclosure to signal terminal panel shall be provided by the CONTRACTOR.

3. Refer to Section 01110.

1.02 REFERENCES

A. Code Compliance:

1. As specified in Section 01410:
   a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.

2. The following codes and standards are hereby incorporated into these Specifications:
   a. National Fire Protection Association (NFPA):
      1) NFPA 70 - National Electric Code (NEC).
      2) NFPA 496 - Purged and Pressurized Enclosures for Electrical Equipment, where applicable.
      3) NFPA 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
   b. Underwriters Laboratories, Inc. (UL):
      1) UL 508 - Industrial Control Equipment.
   c. American National Standards Institute (ANSI):
      1) ANSI B16.5 - Pipe Flanges and Flanged Fittings.
   d. American Petroleum Institute (API):
      1) API RP551 - Process Measurement Instrumentation.
      2) API RP552 - Transmission Systems.
      3) API RP553 - Refinery Control Valves.
      4) API RP554 - Process Instrumentation and Control.
      5) API RP555 - Process Analyzers.
      6) API RP556 - Fired Heaters & Steam Generators.
   e. American Society of Testing and Materials (ASTM):
      1) ASTM A269 - Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   f. International Society of Automation (ISA):
      1) ISA-5.1 - Instrumentation Symbols and Identification.
      2) ISA-5.2 - Binary Logic Diagrams for Process Operations.
      3) ISA-5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.
      4) ISA-5.4 - Instrument Loop Diagrams.
      5) ISA-5.5 - Graphic Symbols for Process Displays.
      6) ANSI/ISA-7.00.01 - Quality Standard for Instrument Air.
      7) ISA-RP - 12.4 - Pressurized Enclosures.
      9) ISA-20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
13) ISA-RP60.3 - Human Engineering for Control Centers.

B. Compliance with Laws and Regulations:
1. Refer to the General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth in:
1. International Society of Automation (ISA).
3. Institute of Electrical and Electronic Engineers (IEEE).
5. Factory Mutual or FM Global (FM).
10. Underwriter Laboratories (UL).

B. Specific Definitions:
1. Control Circuit: Any circuit operating at 120 volts AC or DC or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
2. Panel: An instrument support system that may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these Contract Documents is interpreted as a general term, which includes flat surfaces, enclosures, cabinets and consoles.
3. Power Circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal Circuit: Any circuit operating at less than 50 volts AC or DC, which conveys analog information or digital communications information.
5. Digital Bus: A communication network, such as Profibus, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions and diagnostic information.
6. 2-Wire Transmitter (Loop Powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Specification, two-wire transmitter
refers to a transmitter that provides 4 to 20 mA current regulation of a signal in a series circuit with an external 24 VDC driving potential:
a. Field Bus Communications signal or both.

7. Powered Transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Specification, the produced signal may either be a 4 to 20 mA current signal, a Digital Bus communications signal or both.

C. Acronym Definitions:
1. DPDT: Double-Pole, Double-Throw.
2. ES: Enterprise System: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
3. FAT: Factory Acceptance Test.
5. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
6. HMI: Human Machine Interface: PLC based operator interface device consisting of an alphanumeric display and operator input devices. The HMI is typically a flat panel type of display with either a touch screen or tactile button interface.
7. ICSC: Instrumentation and Control System Contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
8. IJB: Instrument Junction boxes. A panel designed with cord sets to easily remove, replace or relocate instrument signals.
10. IP: Internet Protocol or Ingress Protection.
11. LCP: Local Control Panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
12. LAN: Local Area Network: A control or communications network that is limited to the physical boundaries of the facility.
13. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
14. OIT: Operator Interface Terminal. PC based interface device used for operator interface with the SCADA system.
17. **PCIS**: Process Control and Instrumentation System: includes the entire instrumentation system, the entire control system, and all of the work specified in Division 17 and depicted on the Instrumentation Drawings.

18. **PCM**: Process Control Module: An enclosure containing any of the following devices: PLC, RIO.

19. **PJB**: Power Junction Box: An enclosure with terminal blocks that distribute power to multiple instruments.

20. **PLC**: Programmable Logic Controller.

21. **RIO**: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.

22. **RTU**: Remote Telemetry Unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.

23. **SCADA**: Supervisory Control and Data Acquisition system consists of the computer-based software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software.


25. **SPST**: Single-Pole, Single-Throw


27. **VCP**: Vendor Control Panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

28. **WAN**: Wide Area Network: A control or communications network that extends beyond the physical boundaries of the facility.

### 1.04 SYSTEM DESCRIPTION

**A. General Requirements:**

1. The Work includes everything necessary for and incidental to executing and completing the general requirements for the instrumentation and control system Work described in the Contract Drawings and Specifications and reasonably inferable there from including but not limited to:
   a. Preparing hardware submittals for field instrumentation.
   b. Design, develop, and draft loop Drawings, control panel designs, and all other drawing submittals specified in Division 17.
   c. Prepare the test plan, the training plan, and the spare parts submittals.
   d. Procure all hardware.
   e. Provide all PCIS system hardware and software.
   f. Fabricate panels.
   g. Perform factory tests on panels.
   h. Perform bench calibration and verify calibration after installation.
   i. Oversee and certify installation of the PCIS system.
   j. Oversee, document, and certify loop testing.
   k. Oversee, document, and certify system pre-commissioning.
   l. Conduct the Performance Tests.
   m. Prepare Operation and Maintenance Manuals.
   n. Conduct training classes.
   o. Prepare Record Drawings.
p. Integrate the PCIS with instrumentation and control devices provided under other sections.
q. Develop all requisite loop drawings and record drawings associated with equipment provided under other Divisions of these Specifications and OWNER furnished and existing equipment.
r. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.
s. Perform all required corrective and preventative maintenance.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all: connections, testing, calibration of all equipment furnished by others as well as equipment furnished by the CONTRACTOR, whether or not specifically mentioned but which are necessary for successful operation.

3. Provide the complete operating PCIS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the requirements of the Contract Documents.

4. Coordinate all aspects of the Work between CONTRACTOR and all Subcontractors before bidding to ensure that all costs associated with a complete installation are included. The OWNER is not responsible for any change orders due to lack of coordination of the Work between the CONTRACTOR, the ICSC, the other Subcontractors or Suppliers.

5. Furnish detailed, complete, and thorough operations and maintenance documentation, including, but not limited to: Operations Manuals, Maintenance Manuals, As-Built Wiring Drawings, Training Manuals, As-Built Software Documentation, and all other documentation required to operate, modify, and maintain all parts of the PCIS.

6. Portions of this project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
   a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc) before performing any work.
   b. Provide and document: interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.

7. Revise in a manner as directed by the ENGINEER all I/O and addressing that the ENGINEER determines to be unacceptable as a result of a lack of CONTRACTOR coordination between Contract Documents and all Suppliers.

8. Defective Work:
   a. Refer to the General Conditions.

B. Existing System:
   1. The existing control system is an HSQ Miser SCADA system, which serves the existing Water Quality Control Facility (WQCF).
   2. HSQ RTU's are existing at various process areas of the WQCF and transmit and receive data from a central control facility.
   3. The SCADA system monitors and controls the WQCF through the RTU's.

C. New System:
   1. This project consists of new instrumentation for monitoring and control of:
      a. Effluent pump station and related facilities.
      b. New outfall structure
2. Pump station includes:
   a. Pressure, flow, temperature, and other instruments as shown on the Drawings.
   b. PLC system with panel for control of 4 vertical turbine pumps with variable frequency drives.
   c. Termination of all monitoring and control signals at the signal terminal panel, as shown on the Drawings.
   d. Installation of HSQ RTU and enclosure. HSQ RTU and enclosure will be furnished by the OWNER.
   e. Installation of conduit from the HSQ RTU to the signal terminal panel.
   f. For CONTRACTOR Reference: Wire and programming of the HSQ RTU will be provided by OWNER.
   g. Radio system including radio transceiver, antenna support pole, mast, and antenna.
3. Outfall structure includes:
   a. Pressure, dissolved oxygen, and other instruments as shown on the Drawings.
   b. Radio system including radio transceiver and antenna shall be furnished by OWNER. The CONTRACTOR shall provide the antenna support pole and all other appurtenances shown in detail N200.2. The CONTRACTOR shall also install the radio system, antenna and all appurtenances.

D. Operating Facility:
   1. Refer to Section 01140.
   2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
      a. All outages must be of minimal duration and fully coordinated and agreed to by the OWNER. Adjust the construction to meet the requirements of the OWNER.

1.05 SUBMITTALS

A. General:
   1. Furnish submittals that are fully indexed with a tabbed divider for every component.
   2. Sequentially number pages within the tabbed sections. Submittals and Operation and Maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
   3. Edit all Submittals and Operation and Maintenance Manuals so that the submittal specifically applies to only the equipment furnished. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
   4. Instruct all equipment suppliers of Submittal and Operation and Maintenance Manuals of the requirements in Section 17050.
5. Submittal Requirements:
   a. Submit copies of shop drawings, and product data, in accordance with Section 01330 in addition to the requirements of this Section:
      1) Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
   b. Where Submittals are required, provide a separate submittal for each Specification section. In order to expedite construction, the CONTRACTOR may make more than one submittal per Specification section, but a single submittal may not cover more than one Specification section:
      1) The only exception to this requirement is when one specification section covers the requirements for a component of equipment specified in another section.

6. Exceptions to specifications and drawings:
   a. Include a list of proposed exceptions to the specifications and drawings along with a detailed explanation of each.
   b. Any exceptions to the specification and drawings must be noted and the reason for the exception explained.
   c. If there is insufficient explanation for the deviation, the submittal will be returned requiring Revision and Re-submittal.
   d. ENGINEER approval of any exception is at the sole discretion of the ENGINEER. Furnish all items (materials, features, functions, performance, etc.) that are not listed as exceptions strictly in accordance with the specifications and drawings.
   e. Replace all items that do not strictly meet the requirements of the Specifications, which were not previously approved as exceptions, even if the Submittals contained information indicating the failure to meet the requirements.

7. Submittal Organization:
   a. First page:
      1) Specification Section reference.
      2) Name and telephone number of individual who reviewed submittal before delivery to ENGINEER.
      3) Name and telephone number of individual who is primarily responsible for the development of the submittal.
      4) Place for CONTRACTOR's review stamp and comments.
   b. Next pages:
      1) Provide confirmation of Specification compliance in a tabular form that individually lists each Specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
      2) Include a response in writing to each of the ENGINEER's comments or questions for submittal packages which are re-submitted:
         a) In the order that the comments or questions were presented throughout the submittal.
         b) Referenced by index section and page number on which the comment appeared.
         c) Acceptable responses to ENGINEER's comments are either:
            1) ENGINEER's comment or change is accepted and appropriate changes are made.
(2) Explain why comment is not accepted or requested change is not made.
(3) Explain how requirement will be satisfied in lieu of comment or change requested by ENGINEER.

d) Any re-submittal, which does not contain responses to the ENGINEER’s previous comments shall be returned for Revision and Resubmittal.

e) No further review by the ENGINEER will be performed until a response for previous comments has been received.

c. Remaining pages:
   1) Actual Submittal data:
      a) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
      b) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

8. Specific Submittal requirements:
   a. Furnish the submittals required by each Section or Division 17:
      1) Product Data.
      2) Shop Drawings.
   b. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
   c. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
      1) Uniquely number each wire per the Specifications.
   d. Wire numbers must appear on all equipment drawings.

9. During the period of preparation of submittals, the CONTRACTOR shall authorize direct, informal liaison between the ICSC and the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the ENGINEER, which do not alter the scope of Work or cause increase or decrease in the Contract Price or Times. During this informal exchange, no oral statement by the ENGINEER shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.

10. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ANSI/ISA S5.1:
   a. Employ the nomenclature and numbers designated herein and on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
   b. Replace any other symbols, designations, and nomenclature unique to a manufacturer’s, Suppliers, or Subcontractor’s standard methods with those identified herein and on the Drawings.

11. Furnish submittals in the following general order, each in a separate bound set:
   a. Schedule of Values.
   b. Product Data.
   c. After approval of the Product Data, submit the Project Shop Drawing submittals
   d. Loop Description Submittal.
e. Pump Station PLC software and programming, complete with operator panel HMI configuration and screens.

f. Testing, Calibration and Start-up procedures.

g. Operation and Maintenance Data.

h. Training Submittals.

i. Record Documents.

B. Product Data:

1. General:
   a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these specifications.
   c. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
   d. Legibly cross out options that do not apply or equipment not intended to be supplied.

2. Material and equipment schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and instruments that are proposed:
   b. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

3. Instrument Data Sheets and cut sheets:
   a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hardcopy, for each instrument and component according to ISA S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. Include the following information on the data sheet:
      1) Component functional description used herein and on the Drawings.
      2) Manufacturers model number or other product designation.
      3) Tag number used herein and on the Drawings.
      4) System or loop of which the component is a part.
      5) Location or assembly at which the component is to be installed.
      6) Input and output characteristics.
      7) Scale range with units and multiplier.
      8) Requirements for electric supply.
      9) Requirements for air supply.
     10) Power consumption.
     11) Response timing.
     12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
     13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.
   b. Provide a technical brochure or bulletin (“cut sheet”) for each instrument on the project. Submit with the corresponding data sheets:
      1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
      2) Include a list of tag numbers for which it applies with each brochure or bulletin.
      3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
      4) Cross out models, features, options, or accessories that are not being provided.
      5) Clearly mark and identify special options and features.
   c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

4. Control Panel Hardware Submittal:
   a. Submit the following in one submittal package.
   b. Complete and detailed bills of materials:
      1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
      2) Include all items within an enclosure.
   c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and SCADA equipment.
   d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
   e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
   f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
      1) The manufacturer's model number or other identifying product designation.
      2) Tag and loop number.
      3) System to which it belongs.
      4) Site to which it applies.
      5) Input and output characteristics.
      6) Requirements for electric power.
      7) Device ambient operating requirements.
      8) Materials of construction.

C. Shop Drawings:
   1. General:
      a. Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:
         1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
      b. Show all interfaces between any of the following: instruments, control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, pressure transmitters, signal terminal panels, and other equipment related to the PCIS.
c. Generate all drawings developed for this project utilizing AutoCAD by AutoDesk Version 2004 or later:
   1) Furnish on CD-ROM disks, as well as hard copies on 11 inch by 17 inch plain bond paper.

d. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
   1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
   2) Binder ring size: 2 inches.

e. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
   1) The firm’s registered business name.
   2) Firm’s physical address, email address, and phone number.
   3) OWNER’s name.
   4) Project name and location.
   5) Drawing name.
   6) Revision level.
   7) Personnel responsible for the content of the drawing.
   8) Date.

2. Shop drawing requirements:
   a. Front, side, and rear elevations, and top and bottom views, showing all dimensions.
   b. Locations of conduit entrances and access plates.
   c. Component layout and identification.
   d. Schematic and wiring diagrams with wire numbers and terminal identification.
   e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
   f. Anchoring method and leveling criteria, including manufacturer’s recommendations for the seismic specified in Section 01612 and wind conditions specified in Section 01614.
   g. Weight.
   h. Finish.
   i. Nameplates:
      1) Refer to Section 16075.
   j. Temperature limitations, as applicable.

3. Loop Drawings:
   a. Submit Loop Drawings for every analog, discrete, and fieldbus signal and control circuit:
      1) Provide a Loop Drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
      2) This requirement applies to all signal and control circuits associated with equipment provided under Division 17, Division 16, as well as equipment provided under other Sections including vendor supplied equipment packages and control panels.
   b. Show every instrument and I/O point on at least one Loop Diagram.
   c. Provide a complete index in the front of each bound volume:
1) Index the loop drawings by systems or process areas.
   d. Provide drawings showing definitive diagrams for every instrumentation
      loop system:
       1) Show and identify each component of each loop or system using
          requirements and symbols from ANSI/ISA S5.4 - Instrument Loop
          Drawings as amended by the Contract Drawings, as defined by the
          most recent revision in ISA.
       2) Furnish a separate drawing sheet for each system or Loop Diagram.
   e. In addition to the ISA S5.4 requirements, show the following details:
      1) Functional name of each loop.
      2) Reference name, drawing, and loop diagram numbers for any signal
         continuing off the loop diagram sheet.
      3) Show all terminal numbers, regardless of the entity providing the
         equipment.
      4) MCC panel, circuit, and breaker numbers for all power feeds to the
         loops and instrumentation.
      5) Designation of and, if appropriate, terminal assignments associated
         with, every manhole, pull-box, junction box, conduit, and panel
         through which the loop circuits pass.
      6) Show vendor control panel, instrument panel, conduit, junction box,
         equipment and PCIS terminations, termination identification, wire
         numbers and colors, power circuits, and ground identifications.
      7) If a circuit is continued on another drawing show the name and
         number of the continuation drawing on the Loop Drawing. Provide
         complete references to all continuation drawings whether vendor
         control panels, other Loop Drawings, drawings provided under
         Division 16, or other drawings.
   f. In addition to the above requirements, provide Loop Diagrams in
      accordance with the example loop diagram as indicated on the Drawings.

4. Instrument Installation Drawings:
   a. Submit instrument installation, mounting, and anchoring details for all
      components and assemblies, including access requirements and conduit
      connection or entry details.
   b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation
      detail that pertains to the specific instrument by tag number.
   c. For each detail, provide certification and the hard copies, by the instrument
      manufacturer, that the proposed installation is in accordance with the
      instrument manufacturer’s recommendations and is fully warrantable.
   d. For each detail, provide, as a minimum, the following contents:
      1) Necessary sections and elevation views required to define instrument
         location by referencing tank, building or equipment names and
         numbers, and geographical qualities such as North, South, East,
         West, basement, first floor, etc.
      2) Ambient temperature and humidity where the instrument is to be
         installed.
      3) Corrosive qualities of the environment where the instrument is to be
         installed.
      4) Hazardous rating of the environment where the instrument is to be
         installed.
      5) Process line pipe or tank size, service and material.
      6) Process tap elevation and location
7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
8) Routing of tubing and identification of supports.
9) Mounting brackets, stands, anchoring devices, and sun shades.
10) Conduit entry size, number, location, and delineation between power and signal.
11) NEMA ratings of enclosures and all components.
12) Clearances required for instrument servicing.
13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

5. Control Panel Drawings:
   a. Layout Drawings:
      1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
      2) As a minimum, include the following information:
         a) To scale front, side, and plan views.
         b) Dimensions.
         c) Interior and exterior arrangements.
         d) Mounting information, including conduit entrance location.
         e) Finish data.
         f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
         g) Nameplate legend including text, letter size, and colors.
   b. Wiring and Piping Diagrams:
      1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
      2) Include the following information:
         a) Name of panel.
         b) Wiring and piping sizes and types.
         c) Terminal strip numbers.
         d) Wire tags and labels.
         e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
         f) Electrical control schematics in accordance with ANSI standards.
   c. Installation drawings:
      1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
      2) Provide scaled drawings and show the position of the equipment at its intended installation location.
      3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
      4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

6. Schematic Diagrams:
   a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
   b. Include device and field connection terminal numbers on all schematic diagrams.
c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.

7. Control System Diagram:
   a. Submit a complete set of control system diagrams including the following information:
      1) All PLCs, workstations, printers, communication devices, and communication links:
         a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
      2) All cables required for communication requirements.
      3) Show each component fully annotated with conduit size and number associated with the power source.

D. PLC Software Submittal:
   1. In accordance with Product Data and Shop Drawing general requirements.
   2. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
      a. Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the ENGINEER the ability to identify how each specified requirement or function is met.
   3. A complete listing of the PLC system point I/O database:
      a. Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
      b. Organize on a site-by-site basis, separate by point type.
      c. In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
   4. Preliminary operator panel HMI.

E. Control Descriptions:
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include within the Control Description content:
         1) All specific requirements.
         2) All common requirements that pertain in general to all loops.
         3) Listing all ranges, setpoints, timers, values, counter values, etc.

F. Testing, Calibration, and Start-up Submittal:
   1. General testing submittal requirements are specified in this Section. Additional requirements are specified in Section 17950 and other Sections.
   2. Test Procedure Submittals:
      a. Submit the proposed procedures to be followed during tests of the PCIS and its components in two parts:
         1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
         2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and
checklists. Include a statement of test objectives with the test procedures.
3. Provide certified and witnessed test and calibration checklists for each of the following tests:
   a. Calibration, adjustment, and test details for all components and systems.
   c. Loop Validation Tests:
      1) Loop Validation Certifications:
         a) After the field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the CONTRACTOR, and the OWNER’s Representative, with test data entered, together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.
      d. Pre-commissioning Test.
      e. Performance Test.
4. Factory Acceptance Test:
   a. Include complete test procedures and forms to be used during the test.

G. Operation and Maintenance Manuals:
1. Furnish the ENGINEER with a complete preliminary set of written Operation and Maintenance Manuals 8 weeks before calibration, start-up and/or testing.
2. Furnish in accordance with Section 01782 and the following additional requirements.
3. Submit preliminary sets of these manuals to the ENGINEER for review of format and content:
   a. ENGINEER will return 1 set with comments.
   b. Revise and/or amend as required and submit the requisite number of copies to the ENGINEER 15 days before Pre-commissioning of the systems.
4. Incorporate changes that occur during startup and submit as part of the final manuals.
5. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
6. Include Record Documents and the approved shop drawing submittals, modified for conditions encountered in the field during the work.
7. Include signed results from Calibration, Loop Validation Tests, Pre-commissioning, and Performance Testing.
8. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
9. Provide exploded or other detailed views of all instruments, assemblies and accessory components together with complete parts lists and ordering instructions.
10. Operational Manual:
   a. Prepare and provide a simplified version of the standard manufacturer’s HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
11. Spare Parts List:
   a. Include a priced list of recommended spare parts for all the equipment
      furnished under this Contract:
      1) Include recommended quantities sufficient to maintain the furnished
         system for a period of 5 years.
   b. Annotate the list to indicate which items, if any and quantity are furnished
      as part of this Contract.
   c. Provide the name, address, and phone number of manufacturer and
      manufacturer's local service representative of these parts.

12. Control and SCADA System Software Record Documents:
   a. Include complete documentation of all the software programs provided for
      the entire control and SCADA systems, including:
      1) Listings of all application software on both hard copy and CD-ROM.
      2) Database, both hard copy and CD-ROM.
      3) Developed and documented Source Codes.
      4) Communication protocols.
      5) All documentation necessary to maintain, troubleshoot, modify, or
         update the software system.
      6) SCADA Block Diagram with IP addressing defined on all components
         connected on the network.

13. Organize the Operation and Maintenance Manuals for each process in the
    following manner:
   a. Section A - Process and Instrumentation Diagrams.
   b. Section B - Control Descriptions.
   c. Section C - Loop Drawings.
   d. Section D - Instrument Summary.
   e. Section E - Instrument Data Sheets and Brochures.
   f. Section F - Sizing Calculations.
   g. Section G - Instrumentation Installation Details.
   h. Section H - Test Results.
   i. Section I - Operational Manual.
   j. Section J - Spare Parts List.
   k. Section K - Control and SCADA System Software.

H. Training Submittals:
   a. Develop and submit for review a General Training Plan. Include complete
      descriptions of all planned training classes, a preliminary training schedule,
      a list of all proposed instructors along with resumes, examples of proposed
      training manuals, and a description of any special training tools to be used
      (simulators, self-paced modules, personal computer-based training, etc.).
   b. The ENGINEER will review the General Training Plan. Special emphasis
      will be placed on review of the qualifications of the proposed instructors
      and the timing of the individual courses to maximize their effectiveness. If,
      in the opinion of the ENGINEER, the proposed instructors are not
      sufficiently qualified to conduct the specified training courses, or lack
      experience, where required, on the specific configuration of the system,
      provide more qualified instructors.
   c. Training Course Plan submittals:
      1) For each training course or other training activity, submit a detailed,
         complete outline and agenda for each lesson.
      2) Describe any student pre-requisites for the course or training activity.
3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
4) Submit training materials.
   d. Incorporate all submittal review comments into the course.
   e. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.

I. Record Documents:
1. Furnish in accordance with Section 01770.
2. Provide Record Documents of all instrumentation Drawings.
3. Record Drawing requirements:
   a. Update Record Drawings weekly.
   b. Record Drawings must be fully updated as a condition of the monthly progress payments.
   c. Submit final fully updated Record Drawings upon completion of the Work for final review.
   d. Clearly and neatly show all changes in accordance with Section 01770 and the following:
      1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
4. Shop Drawings:
   a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
      1) Should an error be found in a shop drawing during installation or startup of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
      2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
   b. Provide “As-Built” Shop Drawings for all instrumentation equipment on 11 inch by 17-inch using 20 pound bond paper.
   c. Provide electronic copies of these documents on CD-ROM disks in Autodesk AutoCad Version 2004 and Adobe pdf format. Size all Drawings to be readable and legible on 11-inch by 17-inch media.
5. Submittal Documents:
   a. Provide an interim submittal of Record Documents after the PCIS system Pre-commissioning testing.
   b. Submit final Record Documents as specified in Section 01770.
6. Review and Corrections:
   a. Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit Record Documents returned for correction.

1.06 QUALITY ASSURANCE


B. Furnish all equipment listed by and bearing the label of Underwriters' Laboratories, Incorporated (UL) or of an independent testing laboratory acceptable to the ENGINEER and the Authority Having Jurisdiction.
C. The CONTRACTOR is responsible for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the OWNER’s operations.

B. Shipping Precautions:
   1. After completion of shop assembly, successful Factory Acceptance Test (FAT), pack all equipment, cabinets, panels, and consoles in protective crates and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   2. Place dehumidifiers when required, inside the polyethylene coverings.
   3. Skid-mount the equipment for final transport.
   4. Provide lifting rings for moving without removing protective covering.
   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

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

D. Tagging:
   1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
   2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCIS.
   3. Tag instruments immediately upon receipt in the field.
   4. Prominently display identification on the outside of the package.
   5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

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

1.08 PROJECT OR SITE CONDITIONS

A. Site Conditions:
   1. Provide a PCIS, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic Classification:
      a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612.
   3. Wind:
      a. Provide equipment and construction techniques suitable for the Site wind loading criteria, as specified in Section 01614, except for radio antennas specified otherwise in Section 17750.
   4. Altitude, Temperature and Humidity:
      a. Refer to Section 01610.
b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.

c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer’s guidelines:
   1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not shown on the plans.

5. Area Classifications: Furnish enclosures that match the area classifications as specified or as shown on the Drawings.

6. Site Security:
   a. Abide by all security and safety rules concerning the work on the Site, as specified in Section 01329.

1.09 SEQUENCING

A. General:
   1. Testing requirements are specified in Section 17950 and other Sections.
   2. General scheduling requirements are specified in Section 01324.
   3. Work restrictions and other scheduling requirements are specified in Section 01140.

B. Submit proposed ICSC statement of qualifications:
   1. The ICSC must be approved by the ENGINEER before any other Work commences.

C. Pre-submittal Conferences:
   1. Before producing any submittals, schedule a pre-submittal Conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
   2. The CONTRACTOR, instrumentation and control Subcontractor, electrical Subcontractor, all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
      a. Vendor Control Panels
      b. Switchgear.
      c. Variable Frequency Drives.
      d. Lighting.

D. Factory Acceptance Test (FAT):
   1. Before the delivery and installation of the PCIS system at the job site, but after the procurement, assembly, and configuration of all components, perform the FAT.
   2. Schedule the FAT after receiving approval of the FAT procedures submittal.
   3. Submit a copy of the test procedures including all forms at least 15 days before any scheduled test date.
   4. Notify the ENGINEER of scheduled tests a minimum of 15 days before the date of the test.

E. Loop Validation Test.
1. Notify the ENGINEER of scheduled tests a minimum of 30 days before the estimated completion date of installation and wiring of the PCIS.

2. Complete testing a minimum of 5 days before the Pre-commissioning phase of the project.

F. Training:
   1. Refer to Section 01756.
   2. Complete all training before the pre-commissioning phase of the project may start.
   3. Schedule the training sessions a minimum of 15 days before the start date of the courses.
   4. Submit training manuals to the ENGINEER a minimum of 10 days before starting the training session.
   5. Within 10 days after the completion of each session, submit the following:
      a. A list of all OWNER personnel that attended the session.
      b. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.

G. Pre-Commissioning Test:
   1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Acceptance of the PCIS Pre-Commissioning testing must be provided in writing by the ENGINEER before the performance testing may begin.

H. Provide all special tools and spare parts, refer to Paragraph 1.15 of this Section, before performance testing commences, suitably wrapped and identified.

I. Performance Testing:
   1. Complete Pre-commissioning test a minimum of 5 days before the Performance Test.
   2. Conduct a 30-day Performance Test.

J. Substantial Completion: The following conditions be fulfilled before the PCIS is considered complete:
   1. All submittals have been completed and approved.
   2. The PCIS has been calibrated, loop tested and pre-commissioned.
   3. The OWNER training has been performed.
   4. All required spare parts, expendable supplies, and test equipment have been delivered to the OWNER.
   5. The performance test has been successfully completed.
   6. All debris associated with installation of instrumentation has been removed.
   7. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

1.10 WARRANTY

A. Warrant the PCIS in accordance with the General Conditions:
1.11 SYSTEM STARTUP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the ENGINEER.

1.12 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

C. Provide additional spare parts specified in other sections of Division 17.

D. Submit all special tools and spare parts, suitably wrapped and identified, before performance testing commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the project.

B. Allowable manufacturers are specified in individual instrument and equipment Specifications in other sections of Division 17.

2.02 MATERIALS

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

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

2.03 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of ±0.5 percent of full scale and a minimum repeatability of ±0.25 percent of full scale.
C. Signal Transmission:
   1. Analog Signals:
      a. Furnish analog measurements and control signals that vary in direct linear
         proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 mA
         24 VDC, except as indicated.
      c. Analog signals within enclosures may be 1 to 5 VDC.
      d. Electrically or optically isolate all analog signals from other signals.
      e. All pneumatic signals: 3 to 15 psig.
      f. Discrete input signal: as indicated in the controller hardware specification.
      g. Discrete output signals:
         1) Dry contacts or TRIAC outputs (with express written approval by the
            ENGINEER) as needed to coordinate with the field device.
         2) Provide external terminal block mounted fuse with blown fuse
            indication for all discrete outputs.
         3) Interposing Relays:
            a) Provide interposing relays for all discrete outputs.
      h. Furnish regulated analog signals that are not affected by changes in
         supply voltage or load resistance within the unit’s rating.
      i. Maintain the total 4 to 20 mA loop impedance to 10 percent below the
         published value at the loop operating voltage.
      j. Where necessary, reduce loop impedance by providing current-to-current
         (I/I) isolation amplifiers for signal re-transmission.

D. Discrete Circuit Configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of
      power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on
      the Drawings.

E. Grounding:
   1. Provide control panels with a signal ground bus, isolated from the power
      ground bus:
      a. Provide multiple panels in one location with a common point for signal
         ground bus connection to ground.
   2. Ground single point ground shields and measurement loops at the source
      panel external terminals, unless otherwise noted, by bonding to the control
      panel signal ground bus.
   3. Provide isolating amplifiers within control panels for field equipment
      possessing a grounded input or output, except when the panel circuit is
      galvanically isolated.

2.04 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet
the accuracy requirements in the Contract Documents.
2.05 SOURCE QUALITY CONTROL

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

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the OWNER and ENGINEER to inspect and witness the testing of the equipment at the site of fabrication:
   1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Factory Testing is specified in Section 17950 and other sections of Divisions 16 and 17.

PART 3 EXECUTION

3.01 EXAMINATION

A. Review the existing site conditions and examine all Shop Drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

B. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 INSTALLATION

A. Equipment locations shown on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information shown on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical Shop Drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the OWNER or ENGINEER.

B. Perform all related electrical work in accordance with the applicable Sections of Division 16.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require make reasonable changes in locations and arrangements.
D. Field Instruments Installation:
1. Install field instruments in accordance with the Contract Documents, ANSI/API 550 and 551, and the manufacturer’s instructions.
2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
   a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
   b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
   a. Type of flexible conduit required for the area classification:
   b. Maximum length of 18 inches.
4. Connect field instruments with cable as specified in Division 16, except when the manufacturer requires the use of special cable, or otherwise specified herein:
   a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
   a. Polarity of electric power and signal connections.
   b. Ensure all process connections are free of leaks.
6. Provide a power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
   a. Disconnect enclosure suitable for the area classification:

E. Process Sensing Lines and Air Tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16th-inch per foot to allow for draining of any condensate.
4. Bends:
   a. Use proper tool.
   b. Make bends for parallel lines symmetrical.
   c. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise noted on the Drawings or not compatible with the fluids or atmosphere in the area:
   a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Conduit, Cables, and Field Wiring:
1. Provide all PCIS equipment cables under Division 17.
2. Provide terminations and wire identification as specified in Division 16.
3. Protect all wiring from sharp edges and corners.
4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of Division 16.
G. Equipment Tie-Downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the site.
2. All control panels, VCPs, LCPs, RTUs, PCM’s, etc., shall be permanently mounted and tied down to structures.

H. Instrument Tagging:
1. Refer to Section 16075.
2. Provide all field-mounted instruments with nameplates:
   a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
      1) Affix tags with stainless steel wire fasteners.
3. Provide all back of panel instruments with nameplates:
   a. Engraved with the instrument’s full tag number as indicated on the Drawings:
4. Provide all front of panel instruments with a nameplate:
   a. Engraving to include the instrument’s full tag number and service description.
   b. Secure nameplates to the panel with stainless steel screws.
   c. Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and Conductor Termination:
1. Terminate all cables and conductors on terminal blocks.
2. Terminal Block Enclosures:
   a. Suitable for the area classification.

J. Surge Protection: (applicable to outdoor instruments only):
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
2. Individually fuse each 4-20 mA DC loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:
   a. Protect both power source and signal loop.

3.03 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of PCIS installation in accordance with Section 01450.
2. Provide any assistance necessary to support inspection activities.
3. ENGINEER inspections may include, but are not limited to, the following:
   a. Inspect equipment and materials for physical damage.
   b. Inspect installation for compliance with Drawings and Specifications.
   c. Inspect installation for obstructions and adequate clearances around equipment.
   d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
   e. Inspect equipment nameplate data to verify compliance with design requirements.
   f. Inspect cable terminations.
   g. Inspect/witness instrument calibrations/verifications.
4. Inspection activities conducted during construction do not satisfy inspection requirements outlined in Section 17950.

B. Field Testing is specified in Section 17950. Additional general requirements are specified in Section 01756.

C. Installation Supervision:
   1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
      a. Installation Resources:
      b. Coordinate with the CONTRACTOR regarding installation requirements of the Contract Documents.
      c. Provide technical assistance to installation personnel by telephone:
         1) Furnish installation personnel with at least one copy of the approved submittals, including all installation details.
      d. Periodic inspections during the construction period.
      e. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
      f. Field verify accuracy and calibration of all instruments.

3.04 ADJUSTING

A. Control Valves:
   1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the ENGINEER. It is understood that the CONTRACTOR knows and agrees that changes will be required in the control system software during the Factory Acceptance Tests, the Pre-Commissioning, Performance Testing, Start-up and during the warranty period:

3.05 CLEANING

A. Refer to Section 01770.

B. Vacuum clean all control panels and enclosures before start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label all spare wiring lengths.
2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the ENGINEER.

G. As specified in other sections of the Contract Documents.

3.06 DEMONSTRATION AND TRAINING

A. Demonstration requirements are specified in Section 17950.

B. Training:
   1. General:
      a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.
      b. Conduct all training at the Project Site unless another location is approved by the ENGINEER and OWNER:
         1) Include instruction on the use of all maintenance equipment and special tools provided under the contract.
         2) Present the minimum number of sessions, specified in Table 17050-3.10-T1, for each course in order to satisfy class size restrictions and limitations scheduling OWNER staff.
      c. Schedule individual training classes with the OWNER at least 3 weeks before the start of the class:
         1) Each individual daily training session, travel time excluded:
            a) Minimum duration of 4 hours.
            b) Maximum duration of 7 hours.
            c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
         2) Complete training for maintenance personnel 90-days before Performance Testing.
   2. Training Manuals and Materials:
      a. Furnish training manuals and other materials for training courses.
      b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
      c. The manuals are to serve as teaching aids during presentation of the training classes.
      d. Manuals are to serve as reference material after the training has been completed.

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Minimum Course Length (days per session)</th>
<th>Personnel (Estimated Number of Students)</th>
<th>Minimum Number of Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Overview</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>PLC Hardware</td>
<td>2</td>
<td>5</td>
<td>1</td>
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<tr>
<td>PLC Software</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>HMI Hardware and Software</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Instrument Training</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

3. Training Course Requirements:
   a. System Overview Training:
      1) Furnish training courses that give the OWNER’s supervisory level personnel an overview of all elements of the PCIS System that focus
on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.

b. PLC Hardware Training:
   1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, HMI hardware, control circuits, and analog circuits.
   2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
   3) PLC training may be provided by manufacturer’s certified trainers.

c. PLC Software Training:
   1) Furnish training on PLC software.
   2) Two types of training are required, basic and project-specific:
      a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this project, provided by one of the PLC Manufacturer’s certified trainers.
      b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified member of the ICSC who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this project.

d. HMI Hardware and Software Training:
   1) Provide the following:
      a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
      b) Configuration of tag database.
      c) Creating, editing, and saving display screens.
      d) Troubleshooting.

  e. Instrumentation Training:
      1) Furnish training covering all instruments and control panels.
      2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as described herein and specifically determined in the approved Training Plan.
      3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this project.
      4) Furnish training on the operation of new hardwired controls.

  4. Recording training Sessions:
     a. Record all training.
     b. Produce audio-visual presentations by recording the actual training sessions of the OWNER’S personnel.
     c. Furnish Digital Video Disk (DVD) format.
     d. These disks become the property of the OWNER and cover, in detail, the training for the specific hardware and software of all the systems provided for the project.
     e. Provide all the necessary cameras and recording equipment.
3.07 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

END OF SECTION
SECTION 17100
CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Contractor-developed loop description submittal requirements.
   2. General Programming Requirements.
   3. Common Control Functions:
      a. General control and monitoring functions to be provided throughout the PCIS system.
      1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 and information shown on the drawings.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 17050 - Process Control and Instrumentation Systems General Requirements.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. Hardwired Control - Control circuitry that does not utilize software to initiate functionality.

C. Hardwired Interlocks - A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.

D. Software Interlocks - A safety or protective feature that will interrupt operation of the equipment when the PLC has control.

1.04 SUBMITTALS

A. Refer to Section 17050.
PART 2  PRODUCTS (NOT USED)

PART 3  EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. As specified in Section 17050.

B. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the
      P&IDs for all process values.
   2. Store all adjustable parameters in the PLC, and configure so that an operator
      with sufficient security access can change the parameters from the HMI.
      Update and display the current value at all locations, regardless of where the
      last change was made.
   3. Calculated values:
      a. Program calculations such that division by zero errors cannot occur.
      b. Prevent calculations from generating values that exceed the limits of the
         equipment or data type structures (Integers) internal to the PLC.
      c. Configure counting functions (start counts and operation counts) to allow
         a minimum of 10,000 counts, and to roll-over to zero at an even decimal
         interval (1 followed by 4 or more zeros).
   4. Timers:
      a. Provide programmable settling and proving timers in all control sequences
         for starting and stopping of equipment to allow the process to settle down
         before proceeding with any additional control functions.
      b. Embed the timers in the PLC logic, tune in the field, and list separately as
         part of the software submittal and O&M manual.
   5. PCM status:
      a. Furnish a minimum of one screen that depicts the status of all enclosures
         containing PLCs or I/O in the control system, including but not limited to
         the following:
         1) PLC cabinet over-temperatures from high temperature switch.
         2) Intrusion status on all enclosures equipped with intrusion switches.
         3) AC power failure:
            a) Monitor ahead of UPS.
         4) DC power supply failure:
            a) For redundant power supplies, alarm when either power supply
               fails.
         5) UPS failure signal.
         6) Continued normal operation at each PLC.

C. Common Control Functions:
   1. Incorporate common control functions into all control loops and devices and
      into the control programming, whether or not specifically shown in the specific
      control descriptions or elsewhere in the contract documents.
   2. Alarms:
      a. Generate alarms within the PLC logic.
      b. Indicate alarms at the HMI. Enable acknowledgement from the HMI.
      c. Generate high, high-high, low, and low-low level alarms where indicated:
1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or hasn’t been running long enough to establish flow.

d. Flash all alarm and fail conditions and their respective indicators on the HMI graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.

e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:

f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.

g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
   1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
   2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.

h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.

i. Furnish an alarm silence pushbutton at the HMI with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.

j. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
   1) The lamp test may sequence through blocks of lights.
   2) Minimum on time for each lamp during lamp test 15 seconds.

3. Where a reset is shown for counts, totals and times maintained in the PLC:

a. Provide a reset selection on the HMI that displays the value.

4. Where start counts are shown on the drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:

   1) Display total starts on PCIS screens, and provide a reset function.
   2) Where indicated, calculate number of starts for each day:
      a) Display current day and previous day starts on PCIS displays.
      b) Do not reset daily start count when overall count is reset.

5. Where run time accumulation is shown on the drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hours whenever the running status input indicates that the equipment is running:

a. Display total run time in hours on the HMI.

6. For all monitored analog values:

a. Convert all values to engineering units within the PLC.

b. Totalize flows in the PLC logic:
   1) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
   2) Where no totalizer input is shown, integrate the analog input over time.
   3) Display totals on the HMI.

7. Analog Data Processing:

a. Engineering Units Conversion:
1) Use engineering units for all analog point values. Convert analog inputs to engineering units.

b. Analog Magnitude Checking:
   1) Provide clamps to prevent operator-entered values (setpoints, etc.) that fall outside acceptable limits.

c. Analog value quality:
   1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO, and generate alarms for the following conditions:
      a) Rate of change in excess of acceptable limit:
         (1) Provide a separate rate limit for each value.
      b) Stale value:
         (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm when there is no change in the value for ten times the normal expected scan or communication update.

8. I/O filtering and processing:
   a. Analog Input Filtering:
      1) Provide PLC programming for each analog input to implement an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
      2) Monitor analog input signal quality:
         a) Over range - The input value is above the normal range (typically over 21mA).
         b) Under range - The input value is below the normal range (typically under 3mA, indicating a probable broken connection).
         c) Generate alarms for over or under range inputs.
         d) Do not use over or under range values for control or calculation purposes:
            (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
            (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
      3) Digital Input Filtering (Proving Timer):
         a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing. By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.

9. Instrument scaling:
   a. Provide one or more maintenance screens to display ranges and trigger points for all field instruments:
      1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
      2) For discrete instruments, display calibrated pick-up and drop-out values.
10. **PCIS HAND-OFF-AUTO:**
   a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCIS, accessed from the HMI with sufficient security, to provide the following operating modes:
      1) **PCIS AUTO:** The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
      2) **PCIS HAND:** Enables PCIS Manual control where control decisions are made by an operator through the PCIS START-STOP, OPEN/CLOSE, or other selections as indicated.
      3) **PCIS OFF:** Automated PCIS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
      4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

11. Display the current status of all operator selections (PCIS HAND/AUTO, PCIS START/STOP, etc.) on HMI.

12. **Permissives:**
   a. Implement software permissives where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software permissives when equipment is operating in PCIS AUTO or PCIS HAND:
      1) Where indicated, provide a selection to bypass software permissives for maintenance functions. This option shall only be selectable in PCIS Manual.
   b. Use hard-wired permissives for equipment protection where indicated.

13. **Process control algorithms:**
   a. Jog and Hold - Unless otherwise indicated, use Jog and Hold control algorithms where possible:
      1) When the error between process variable and setpoint is beyond a setpoint deadband:
         a) Jog valve or ramp speed in the required direction for a preset “Jog Time” or until the process variable reaches or passes the setpoint.
         b) Then Hold speed or position through a setpoint “Hold Time.”
         c) Continue alternating Jog and Hold until the error is less than the deadband.
      2) Provide operator access to Jog Time and Hold Time setpoints from the OIT.
   b. **PID algorithms** - Use where indicated:
      1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
         a) Display Output, CV.
         b) Display Setpoint, SP.
         c) Display Process Variable, PV.
         d) Allow for operator selection of Automatic or Manual control of the output.
e) Under Manual control of output allow the Operator to enter the desired output value.
f) Allow for input of the three Proportional, Integral and Derivative tuning parameters.
g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCIS), or when the equipment has reached a physical limit.
h) When controlled equipment is being operated in remote PCIS HAND, configure the PID function to track the process variable to allow bumpless transfer between Manual and Automatic modes.
i) Where indicated provide selectable slew rates with adjustable set points to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.

14. Motor Control:
   a. Monitor the device’s LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
      1) Display current REMOTE status on the HMI screens.
   b. Monitor the device’s running status from the starter auxiliary or run status input:
      1) Display the current status (running or stopped) on the PCIS screens.
      2) Use status to calculate total run time and daily run time, and to count total starts.
      3) For motors 200HP and greater, provide software to prevent exceeding the manufacturer’s recommended maximum starts per hour.
   c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of HMI AUTO or PCIS HAND control modes based upon operator selection using the HMI screens.
   d. Starting, stopping and running when the device LOR is in LOCAL:
      1) With the LOR switch in the Local position, the motor is controlled by the START and STOP pushbuttons.
      2) With the LOR switch in the OFF position, the motor is prohibited from running.
      3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
   e. Starting, stopping and running when the device LOR is in REMOTE:
      1) When the PLC has issued a START command, LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable “Start Control Activation” timer:
         a) Provide “Start Control Activation” timers for each piece of controlled equipment:
            (1) If the LOR and required running status do not change, and the PLC does not receive running status within the “Start Control Activation” time period:
               (a) De-activate the output.
               (b) Place the device in a “Failed” state.
               (c) Generate a “Failed to Start” alarm.
(d) A “Failed to Start” alarm shall be reset by the operator by selecting a reset target at the HMI before the PLC executes a start command.

2) When the PLC has issued a STOP command, LOR is in REMOTE, and the device is not reported to be stopped, start the “Stop Control Activation” timer:
   a) Provide “Stop Control Activation” timers for each piece of controlled equipment:
      (1) If the LOR and required stopped status do not change, and the PLC does not receive the not-running status within the “Stop Control Activation” time period:
         (a) Keep the RUN output off or the STOP output on.
         (b) Place the device in a “Failed” state.
         (c) Generate a “Failed to Stop” alarm.
         (d) A “Failed to Stop” alarm shall be reset by the operator by selecting a reset target at the HMI before the PLC executes a start command.

3) If the PLC detects a change in the status of a device that was running to stopped, or that was stopped to running and this change was not initiated by PLC command, and the device LOR is in REMOTE.
   a) Provide “Discrepancy Control Activation” timers for each piece of controlled equipment:
      (1) If the LOR and running status do not change within the “Discrepancy Control Activation” time period:
         (a) If the output is activated, deactivate the output.
         (b) Generate a discrepancy alarm for the device at the HMI.
         (c) Unless shown otherwise, automatically reset the alarm when there is no longer a discrepancy in running status between the device and the PLC.

f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.

g. Connect motor starter overload relays to stop the motor before de-energizing the motor starter coil. Provide indication to PLC when overload alarm occurs. PLC shall not attempt to start motor until the overload is no longer active.

h. Unless shown otherwise, power motor winding heaters from the starter control power transformer through a normally closed starter auxiliary contact.

i. Simultaneous starts:
   1) Prevent more than one motor-driven load 25 HP or larger in the same facility from starting concurrently:
      a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).

   2) Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.
15. Gate and valve control:
   a. Monitor the device’s LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
      1) Display current REMOTE status on the HMI.
   b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCIS AUTO, or OPEN was selected in PCIS HAND):
      1) Initially set “Open Activation” time to twice the normal opening time.
      2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:
         a) De-activate the open output.
         b) Place the device in a “Failed” state.
         c) Generate a “Failed to Open” alarm.
   c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCIS AUTO, or CLOSE was selected in PCIS HAND):
      1) Initially set “Close Activation” time to twice the normal closing time.
      2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
         a) De-activate the close output.
         b) Place the device in a “Failed” state.
         c) Generate a “Failed to Close” alarm.
   d. For modulating valves (valves controlled from either a 4-20mA signal or digital communications command) with position feedback, start a “Position Error” timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
      1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
      2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
      3) Initially set the “Position Error” time to 60 seconds.
      4) If the LSR position does not change, and position error stays outside of the setpoint error through the “Position Error” time period:
         a) Hold position output.
         b) Place the device in a “Failed” state.
         c) Generate a “Position Fail” alarm.
   e. Provide separate time delay settings for each function and for each device.
   f. If the valve position inputs indicate an impossible state (i.e. valve open and closed at the same time), place the device in a “Failed” state and generate an “Illegal State” alarm.
   g. Re-establish PLC control of a device in a “Failed” state only after an operator selects the reset target for the respective valve at the HMI.
   h. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
3.02 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

END OF SECTION
SECTION 17101

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Loop Descriptions:
      a. Specific control requirements and functional descriptions for individual
         control loops.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract
   Documents, and submit in accordance with Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation
      of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for
      individual raw water pumps, only 1 loop description need be developed and
      the remaining loops may reference that loop description.
B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired Control:
      a. Detailed description of the control functions at the Local Level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Push buttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired Interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC Control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software Interlocks:
   8. HMI Control:
      a. Detailed description of the operator controls.
   9. Indicators and Alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   10. Failure Modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 29.01 - Title: Outfall Pump Station Pump Control
1. References:
   a. OP-N-01.
   b. OP-N-02.

2. Abstract:
   a. The outfall pump station receives effluent from the water reclamation facility and discharges effluent into a force main for ultimate discharge at the river outfall. There are four variable speed vertical turbine pumps that can be used to pump from the pump station wetwell to the force main. Normally, three of the four pumps are in-service in a lead-lag1-lag2 configuration. The fourth pump is a jockey pump, which can be used in the when flows into the pump station wet-well are low.

3. Hardwired Control:
   a. When the LOR switch for each pump is in Local, the pump can be controlled using start/start and speed controls at the respective VFD.

4. Hardwired Interlocks:
   a. The pump will shutdown on failure of the respective VFD.
   b. Low level in the wet well.
   c. High motor temperature.
   d. High Vibration.
   e. High Bearing Temperature.

5. PLC Control:
   a. Primary level control loop operation
      1) Control system selects a valid level signal from one of two level transmitters. If none is found control system primary level control loop shuts down.
      2) While level signal is valid based on magnitude of the level signal, pump controller shall start one, two, or three pump VFD’s, as described below to regulate the respective pump speed.
      3) The operator shall be able to designate the lead, lag1, and lag2 pump at the panel HMI. The operator shall also be able to designate if automatic alternation of lead, lag1, and lag2 pump shall be enabled.
      4) The operator shall be able to select a start and stop level setpoint in the wetwell.
      5) As the level in the wetwell rises above the start setpoint, (initially at 64 ft. elevation) the lead pump shall start at an operator selected speed (initially 60%). As the level continues to rise the lead pump speed shall proportionately increase speed to 70%.
         a) The operator shall be able to set the gain of this control loop in units of change in percent speed per change in wetwell level. The gain will initially be set at 20% per foot.
      6) If the level continues to rise the lag pump shall start at 60% when the lead pump reaches 70% speed. The lag pump shall ramp from 60% to 70% at an operator selected ramp up rate (initially 0.5% per second). After the lag pump reaches 70% speed, both the lead and lag pumps shall proportionately increase as the level continues to rise.
      7) If the level continues to rise and the lead and lag pumps have reached an operator selected speed (initially 90%) The lag2 pump shall start at 60% speed and increase speed at the ramp up rate until the speed of the lag2 pump is within an operator selected deadband of the speed of the lead and lag pumps (initially 4%), at which time
the speed of the lag2 pump shall match the speed of the lead and lag pumps.

8) When the level in the wetwell decreases and when lead, lag1, and lag2 pumps are operating, the pumps shall proportionately decrease speed. When the pump speed decreases to an operator selected speed (initially 85%) the lag2 pump shall ramp down to 60% speed and shut down.

9) When the level in the wetwell decreases and when lead and lag1 pumps are operating, the pumps shall proportionately decrease speed. When the pump speed decreases to an operator selected speed (initially 67%) the lag1 pump shall ramp down to 60% speed and shut down.

10) When the level in the wetwell continues to decrease and when the lead pump is operating, the pump shall proportionately decrease speed. When the lead pump speed decreases to an operator selected speed (initially 60%) and the wetwell level is less that the pump stop setpoint, the lead pump shall shut down.

b. Backup pump operation

1) In the event that the lead pump fails, rotate the pumps as follows:
   a) Standby pump becomes Lag2 pump
   b) Lag2 pump becomes Lag1 pump
   c) Lag1 pump becomes Lead pump
   d) The failed pump becomes the Standby pump with failed indication at the HMI and as indicated on the drawings.

2) In the event that the lag1 pump fails, rotate the pumps as follows:
   a) Standby pump becomes Lag2 pump
   b) Lag2 pump becomes Lag1 pump
   c) The failed pump becomes the Standby pump with failed indication at the HMI and as indicated on the drawings.

3) In the event that the lag2 pump fails, rotate the pumps as follows:
   a) Standby pump becomes Lag2 pump
   b) The failed pump becomes the Standby pump with failed indication at the HMI and as indicated on the drawings.

4) Startup of the standby pump on any of the failure modes shall occur as follows:
   a) Start pump at 60% speed.
   b) Ramp the pump up to the speed of the other pumps in operation using the operator selected ramp up rate.

5) Startup of the standby pump shall be accomplished in a manner to reduce pressure surges in the pipeline.

6. Software Interlocks:
   a. Prohibit operation of the pumps if wetwell level is less than an elevation of 63 feet.

7. HMI Control:
   a. As indicated on the Drawings and Section 17100

8. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.

9. Failure Modes:
   a. As indicated on the Drawings and Section 17100.
3.02 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

END OF SECTION
SECTION 17201

LEVEL MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Ball Float Level Switch.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments
   are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are
         compatible with the process conditions and physical installation.
C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ball Float Level Switch:
      a. Siemens Water Technologies Corp 9G-EF.
      b. ITT Flygt Model ENM-10.

2.02 MANUFACTURED UNITS

A. Ball Float Level Switch:
   1. General:
      a. Free hanging, encapsulated body with a switch to determine position of float.
   2. Element:
      a. Mechanical switch encapsulated in waterproof floating polypropylene ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
      b. The length of the PVC cable shall be , at a minimum, equal to sump depth plus 5 feet.
      c. Float: Provide type 316SS, minimum 3 inches in diameter. The float shall provide a minimum of 2 pounds of buoyancy in solutions with specific gravity of 1 and shall have an operating temperature rating of -30 degrees Fahrenheit to +150 degrees Fahrenheit.
      d. Mercury switches are not acceptable.
      e. Lead Wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
   3. Switch:
      a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
      b. Provide the number of floats per level system as shown on the Drawings.
      c. Suspend ball float and adjust for level setpoint as required.
4. Components:
a. Floats shall include type 316 stainless steel clamp and brackets and 1/4 inch cable to allow testing of the float without entering the basin or wet well.
b. Provide strain relief at both ends of the float cable.

2.03 SOURCE QUALITY CONTROL
A. Refer to Section 17050.

PART 3 EXECUTION
3.01 INSTALLATION
A. Refer to Section 17050.
B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL
A. Refer to Section 17050.

3.03 ADJUSTING
A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING
A. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING
A. Refer to Section 17050.
B. Demonstrate performance of all instruments to the ENGINEER before commissioning.
C. Furnish 4 hours of OWNER training.

3.06 PROTECTION
A. Refer to Section 17050.

3.07 SCHEDULES
A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be shown on the Drawings, in the Specifications or both.
### A/E: Carollo Engineers

#### LEVEL SWITCHES

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**Notes:**

CONFORMED – May 2012

pw://Carollo/Documents/Client/CA/Turlock/6918B11/Specifications/17201 (Conformed)
SECTION 17302
FLOW MEASUREMENT - MAGNETIC FLOWMETERS

PART 1  GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Full-body magnetic flowmeters.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Endress-Hauser - Promag 53.
   2. Rosemount - 8700.
   3. Krohne - IFC.
   4. Toshiba - LF.
   5. Yokogawa - AXF.
   6. Siemens - Sitrans F.
   7. ABB - Watermaster.

2.02 MANUFACTURED UNITS

A. Magnetic Flowmeter:
   1. General:
      a. Magnetic flowometers obtain the flow velocity by measuring the changes of
         induced voltage of the conductive fluid passing across a controlled
         magnetic field.
      b. Complete zero stability shall be an inherent characteristic of the flowmeter
         system.
      c. Include for each magnetic flowmetering system:
         1) A metering tube with electrodes (sensor).
         2) Signal cable.
         3) Transmitter integral or remote as indicated on the Drawings.
         4) Flowmeter grounding rings.
   2. Performance requirements:
      a. Accuracy:
         1) 0.25 percent of flow rate from 10 to 100 percent of full scale for
            velocities ranging between 1.9 to 10 feet per/second.
      b. Repeatability:
         1) 0.25 percent of rate.
3. Element:
   a. Metering Tube:
      1) Constructed of carbon steel (unless specifically noted otherwise in the Instrument Data Sheets or Instrument Index) with flanged connections to match with piping material.
      2) Liner in conformance with:
         a) Manufacturer’s recommendations for the intended service.
         b) NSF Certified.
   3) Electrodes in conformance with:
      a) Manufacturer’s recommendations for the intended service.
      b) Utilize a minimum of 2, self-cleaning electrodes.
   4) Meter terminal housing NEMA 4X.
   5) Meter coating consisting of epoxy painted finish.
   6) Components:
      a) 2 grounding rings:
         (1) Which are in conformance with the manufacturer’s bore and material recommendation for the meter’s intended service.
         (2) Designed to protect and shield from abrasion of the liner’s edge interface at the meter’s end.

4. Transmitter:
   a. Power supply:
      1) 120 VAC.
      2) Power consumption: 60 VA maximum.
   b. Outputs:
      1) Isolated 4-20mA DC with HART communication protocol.
      2) Relay outputs:
         a) 1 Form C contact.
         b) Rated 5 amps at 120 VAC.
         c) Programmable.
   c. Microprocessor-based signal converter/transmitter.
   d. Utilize DC pulse technique to drive flux-producing coils.
   e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
   f. Operator keypad interface.
   g. Integral zero return to provide a consistent zero output signals in response to an external dry contact closure.
   h. Integral low flow cut-off zero return.
   i. Empty Pipe Detection.
   j. Programmable parameters including:
      1) Meter size.
      2) Full-scale flow rate.
      3) Magnetic field frequency.
      4) Time constant.
   k. Data retention for a minimum of 5 years without auxiliary main or battery power.
   l. Self-diagnostics and automatic data checking.
   m. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
   n. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-29 to 60 degrees Celsius).
2.03 ACCESSORIES
A. Stainless steel tag - labeled to match the Contract Documents.
B. Provide sunshades for all transmitters located outdoors.
C. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

2.04 SOURCE QUALITY CONTROL
A. Refer to Section 17050.
B. Factory calibrate each flowmetering system at a facility that is traceable to the National Institute of Standards and Technology (NIST).
C. A real-time computer generated printout of the actual calibration data indicating apparent and actual flows at 20 percent, 40 percent, 60 percent, 80 percent and 100 percent of the calibrated range shall be submitted to the ENGINEER at least 30 days before shipment of the meters to the project site.

PART 3 EXECUTION

3.01 INSTALLATION
A. Refer to Section 17050.
B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL
A. Refer to Section 17050.
B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING
A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING
A. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING
A. Refer to Section 17050.
B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

C. Furnish 4 hours of OWNER training.

3.06 PROTECTION

A. Refer to Section 17050.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.
### A/E: Carollo Engineers

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Notes:

END OF SECTION
SECTION 17401
PRESSURE/VACUUM MEASUREMENT - DIAPHRAGM SEALS

PART 1  GENERAL

1.01  SUMMARY

A.  Section includes requirements for:
   1.  Diaphragm seals.

B.  Related Sections:
   1.  The Contract Documents are complementary; what is called for by one is
       as binding as if called for by all.
   2.  It is the CONTRACTOR’s responsibility for scheduling and coordinating
       the Work of subcontractors, suppliers, and other individuals or entities
       performing or furnishing any of CONTRACTOR’s Work.
   3.  The following Sections are related to the Work described in this Section.
       This list of Related Sections is provided for convenience only and is not
       intended to excuse or otherwise diminish the duty of the CONTRACTOR
       to see that the completed Work complies accurately with the Contract
       Documents.
       a.  Section 01330 - Submittal Procedures.
       b.  Section 17050 - Common Work Results for Process Control and
           Instrumentation Systems.

C.  Provide all seals identified in the Contract Documents.

1.02  REFERENCES

A.  Refer to Section 17050.

1.03  DEFINITIONS

A.  Refer to Section 17050.

1.04  SUBMITTALS

A.  Furnish submittals in accordance with Sections 01330 and 17050.

B.  Additional Requirements:
   1.  Product Data:
       a.  Manufacturer’s installation instructions.
       b.  Seal type.
       c.  Body materials.
       d.  Diaphragm material.
       e.  Fill fluid type.
       f.  Seal size.
       g.  Options.
       h.  Process connection.
1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm Seals:
   1. For, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 psi: One of the following or equal:
      a. Ashcroft, Type 301.
      b. Mansfield and Green, Type LG.
      c. Wika.
      d. Rosemount.
   2. For liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 psi: One of the following or equal:
      a. Ashcroft, Type 101.
      b. Mansfield and Green, Type RG.
      c. Wika.
      d. Rosemount.
2.02 MANUFACTURED UNITS

A. Diaphragm Seals:
   1. General:
      a. Diaphragm seal and pressure instrument shall be assembled by
         pressure instrument manufacturer and shipped as an assembly.
   2. Requirements:
      a. Seal Type: Welded.
      b. Process Connection: 1 inch NPT.
      c. Instrument Connection: 1/2 inch NPT.
      d. Provide 1/4-inch flushing connection in diaphragm housing or
         provide flushing ring.
      e. Provide fill/bleed connection.
      f. Provide bonded diaphragm.
      g. Mounting: As indicated in the Contract Documents.
      h. Nuts and Bolts: 316 stainless steel.
      i. Materials of Construction:
         1) Sewage, sludge, liquids containing solids, and liquids with
            pulsating flow having pressures less than or equal to 15 psi:
            a) Diaphragm: Viton.
            b) Lower Housing: 316 stainless steel.
            c) Upper Housing: Manufacturer's standard.
            d) Fill Fluid: Silicon oil.
         2) Sewage, sludge, liquids containing solids, and liquids with
            pulsating flow having pressures greater than 15 psi:
            a) Diaphragm: 316 stainless steel.
            b) Lower Housing: 316 stainless steel.
            c) Upper Housing: Manufacturer's standard.
            d) Fill Fluid: Silicon oil.
         3) Other Process Fluids: As recommended by manufacturer and
            with Engineer's approval.

2.03 ACCESSORIES

A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Refer to Section 17050.
B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. Refer to Section 17050.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. Refer to Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.08 PROTECTION

A. Refer to Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.

END OF SECTION
SECTION 17402
PRESSURE/VACUUM MEASUREMENT - INSTRUMENT VALVES

PART 1   GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Valve manifolds and instrument valves.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.

C. Provide all valve manifolds and instrument valves identified in the Contract
   Documents.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Additional Requirements:
   1. Product Data:
      a. Valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop Drawings:
      a. Mounting details for all manifold valves.
1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve Manifold Manufacturers: One of the following:
   1. Anderson Greenwood.
   2. Hex Valve.
   3. Noshok.
   4. Rosemount.

B. Block and Bleed Valve Manufacturers: One of the following:
   1. Anderson Greenwood.
   2. Hex Valve.

C. Gauge Valve Manufacturers: One of the following:
   1. Anderson Greenwood.
   2. Hex Valve.
2.02 MANUFACTURED UNITS

A. Valve Manifolds:
   1. General:
      a. Provide 2-Valve, 3-valve, blowdown type 5-valve, or metering type 5-valve
         manifolds as specified in Division 17.
      b. Valve manifolds shall have one-piece bonnet with a metal to metal seal to
         the valve body below the bonnet threads.
   2. Requirements:
      a. Bonnet lock pin to prevent accidental loosening.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Manifold valves shall have straight through portion for bi-directional flow
         and easy roddable cleaning.
      e. Manifold valves shall allow for direct or remote instrument mounting.
      f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves
         and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
      g. Materials of Construction:
         1) Body Material: 316 Stainless Steel.
         2) O-Ring: Teflon.
   h. 2-Valve Manifolds:
      i. 1 isolation valve and 1 drain/vent and calibration valve.
   i. 3-Valve Manifolds:
      j. 2 isolation valves and 1 equalizing valve for differential pressure
         applications.
      k. Blowdown 5-Valve Manifold:
      l. 2 isolation valves, 1 equalizing valve, 2 blowdown valves for
         differential pressure applications.
      m. Metering 5-Valve Manifold:
      n. 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration
         valve for differential pressure applications.

B. Block and Bleed Valves:
   1. General:
      a. Valve shall provide process isolation and venting/dRAINING capabilities.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
   2. Requirements:
      a. Materials of Construction:
         1) Body Material: 316 Stainless Steel.
         2) O-Ring: Teflon.

C. Gauge Valves:
   1. General:
      a. Valve shall provide process isolation from pressure instrument.
      b. Gas leak tested metal to metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
   2. Requirements:
      a. Materials of Construction:
         1) Body Material: 316 Stainless Steel.
         2) O-Ring: Teflon.
2.03 ACCESSORIES
   A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
   B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL
   A. Refer to Section 17050.

PART 3  EXECUTION

3.01 INSTALLATION
   A. Refer to Section 17050.
   B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL
   A. Refer to Section 17050.
   B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING
   A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
      1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING
   A. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING
   A. Refer to Section 17050.
   B. Demonstrate performance of all instruments to the ENGINEER before commissioning.
   C. Furnish 1 hours of OWNER training.

3.06 PROTECTION
   A. Refer to Section 17050.
3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.

END OF SECTION
SECTION 17404
PRESSURE/VACUUM MEASUREMENT - GAUGES

PART 1    GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Pressure/Vacuum gauges.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.
      c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and
         Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.

C. Provide all instruments identified in the Contract Documents

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Additional Requirements:
   1. Product Data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and
         pulsation dampeners.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050.
B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING
   A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS
   A. Refer to Section 17050.

1.08 WARRANTY
   A. Refer to Section 17050.

1.09 MAINTENANCE
   A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Manufacturers: One of the following:
      1. Ashcroft:
         a. Maximum pressure greater than or equal to 10 PSI: Model 1279.
      2. Wika.
      3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS
   A. General:
      1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

   B. Performance requirements:
      1. Pressure Range:
         a. As indicated in the Contract Documents.
      2. Accuracy:
         a. ±1.0 percent of span after friction errors are eliminated by tapping or vibration.
         b. Maximum allowable friction inaccuracy: ±1.0 percent of span.
3. Element:
   a. Where the maximum pressure is less than 10 PSI, provide socket and
      bellows; for all other pressure ranges, employ a Bourdon tube.
   b. Socket tips for bellows and Bourdon tube:
      1) Materials: Type 316 Stainless Steel.
   c. Overpressure: Minimum 130 percent of maximum range pressure without
      damage to gauge or sensing element.
   d. Wetted Materials: 316 Stainless Steel.
   e. Dial Gauge: As indicated in Instrument Schedule.
   f. Dial Size: 4-1/2 inches.
   g. Dial case material: Stainless Steel.
   h. Provide safety gauge with rupture disk and blow out back.
   i. Dial face: Gasketed Shatterproof Glass.
   j. Provide Gauge locks where possible.
   k. Connection and Mounting:
      1) Direct mounted and suitable for outdoor installation.
      2) 1/2 inch NPT.
      3) Connection Material: Stainless Steel.
   l. Pointer: Externally adjustable.

2.03 ACCESSORIES

   A. Pulsation Dampeners and Snubbers:
      1. Provide pulsation dampener or snubber with each pressure gauge installed on
         discharge of positive displacement type pump.
      2. Provide piston-type snubber if pressure spikes will exceed 130 percent of
         gauge maximum range.
      4. Mount pulsation dampener or snubber integrally to the pressure gauge.
      5. Connection: 1/2-inch NPT.

   B. Provide diaphragm seals as specified in the Contract Documents and in Section
      17401:
      1. Diaphragm seal and pressure gauge shall be assembled by Manufacturer and
         shipped as an assembly.

   C. Provide means for gauge isolation as specified in Section 17402:
      1. Mount valve manifold integrally to the gauge.
      2. Valve manifold and pressure gauge shall be assembled by Manufacturer and
         shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

   A. Refer to Section 17050.

   B. Factory calibrate each pressure gauge at a facility that is traceable to the National
      Institute of Standards and Technology (NIST).

   C. Provide complete documentation covering the traceability of all calibration
      instruments.
PART 3 EXECUTION

3.01 (NOT USED)

3.02 (NOT USED)

3.03 INSTALLATION

A. Refer to Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. Refer to Section 17050.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. Refer to Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning:
   1. Furnish 0.5 hours of OWNER training.

3.08 PROTECTION

A. Refer to Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.
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**Notes:**
Refer to Specification 17402 for additional instrument valve requirements.

END OF SECTION
SECTION 17405
PRESSURE/VACUUM MEASUREMENT - DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Pressure transmitters and indicators.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.
      c. Section 17401 - Pressure-Vacuum Measurement - Diaphragm and Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. Lower Range Value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   2. Calibrated Range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.
   3. Upper Range Value (URV): Highest pressure that the pressure transmitter is capable of measuring.
1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Product Data:
   1. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Rosemount: 3051C Series.
   2. Yokogawa: EJA Series.
   3. ABB: 264 Series.
   4. Endress & Hauser: Cerabar S Series.
   5. SMAR: LD300 Series.
2.02 MANUFACTURED UNITS

A. Pressure Transmitters – Direct:
   1. General:
      a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
   2. Performance requirements:
      a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      b. Accuracy:
         1) Reference Accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
         2) Total Performance Accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
         3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
   3. Element:
      a. Diaphragm type transducer integral to pressure transmitter.
      b. Diaphragm material: Stainless steel or ceramic.
      c. Process Material Compatibility:
         1) Verify all material compatibilities with the instrument manufacturer.
         2) Diaphragm fill material shall be nontoxic.
      d. Process Connection: As indicated in the Instrument Data Sheets or Instrument Index.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - 2 wire loop powered.
         2) Power consumption: 3 VA maximum.
      b. Outputs:
         1) Isolated 4-20mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Local Display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      f. Enclosure: NEMA 4X
      g. Over range Protection: To maximum process line pressure.
      h. Conduit: 1/2 inch male NPT.
   5. Components:
      a. Transmitter Mounting:
         1) As indicated in the Instrument Data Sheets or Instrument Index.
         2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 17402:
   1. Mount valve manifold integrally to the transmitter.
   2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
3. Provide remote or integral diaphragm seals as indicated in the Instrument Data Sheets or the Instrument Index, and as specified in Section 17401.

B. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

C. Furnish 2 hours of OWNER training.

3.06 PROTECTION

A. Refer to Section 17050.
3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.
## PRESSURE TRANSMITTERS

**A/E:** Carollo Engineers

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**Notes:**
Refer to Specification 17402 for additional instrument valve requirements.
SECTION 17407
PRESSURE MEASUREMENT - SUBMERSIBLE

PART 1    GENERAL

1.01 SUMMARY
A. Section includes requirements for:
   1. Submersible pressure transmitters.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES
A. Refer to Section 17050.

1.03 DEFINITIONS
A. Refer to Section 17050.

1.04 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330, and 17050.

1.05 QUALITY ASSURANCE
A. Refer to Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are
   compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are
         compatible with the process conditions and physical installation.
C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS
A. Refer to Section 17050.

1.08 WARRANTY
A. Refer to Section 17050.

1.09 MAINTENANCE
A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Submersible level measurement with 2-wire integral transmitter:
   1. One of the following:
      a. Mercoid PBLT2
      b. No substitution permitted

2.02 MANUFACTURED UNITS
A. Submersible level measurement with 2-wire integral transmitter:
   1. General:
      a. Pressure is measured through a ceramic measuring cell and converted to linear pressure measurement.
      b. Each submersible pressure transmitter system shall include:
         1) Signal cable.
         2) Transducer with integral transmitter.
         3) Transmitter cable termination box.
   2. Performance requirements:
      a. Element: piezoresistive element encased in 316 stainless steel housing
      b. Accuracy: 0.25 percent of range.
      c. Repeatability: 0.25 percent of full scale.
      d. Range: 0-5 psig (11.54 feet, water column)
      e. Service: Tertiary effluent
      f. Sensor Wetted Materials: 316, 316 stainless steel, Buna-N
      g. Cable Wetted Materials: ETFE, polyurethane
      h. Temperature Operating Limits: 0 - 200 degrees F.
      i. Compensated Temperature Range: 0 – 180 degrees F.
      j. Thermal Effect: less than 0.02% per degree F.
      k. Pressure Limit: 2 times full scale
      l. Power Requirement: 15 - 30 volts DC
m. Output Signal: 4-20 milliamperes DC  

n. Response Time: 50 milliseconds  
o. Loop Resistance: 850 ohms at 30 volts DC  
q. Weight: 4.3 pounds  
r. Protection: Lightning and Surge  

2.03 SOURC E QUALITY CONTROL  

A. Refer to Section 17050.  

B. Factory calibrate each instrument at a facility that is traceable to the National Institute of Standards and Technology (NIST).  

C. Provide a real-time computer generated printout of the actual calibration data indicating apparent and actual levels at 20 percent, 40 percent, 60 percent, 80 percent and 100 percent of the calibrated ranges. Submit to the ENGINEER and included in the O&M.  

D. Provide complete documentation covering the traceability of all calibration instruments.  

PART 3 EXECUTION  

3.01 (NOT USED)  

3.02 (NOT USED)  

3.03 INSTALLATION  

A. Refer to Section 17050.  

3.04 FIELD QUALITY CONTROL  

A. Refer to Section 17050.  

B. Provide manufacturer’s services to perform start-up and calibration or verification.  

3.05 ADJUSTING  

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:  
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.  

3.06 CLEANING  

A. Refer to Section 17050.
3.07 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

C. Furnish 1 hours of OWNER training.

3.08 PROTECTION

A. Refer to Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.
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**A/E:** Carollo Engineers

**Contractor:**

**Project:**

**Customer:**

**Plant:**

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**Notes:**

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Dissolved Oxygen (DO) analyzer.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. Refer to Section 17050.


1.03 DEFINITIONS

A. Refer to Section 17050.

B. DO - Dissolved oxygen.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

B. Provide all parts, materials, fluids, etc. necessary for maintenance and calibration purposes for a period of one year:
   1. Deliver all supplies before substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   2. Or equal.

2.02 MANUFACTURED UNITS

A. Dissolved Oxygen (DO) Analyzer:
   1. General:
      a. Dissolved oxygen analyzer for continuous monitoring of dissolved oxygen (DO) in liquid.
   2. Performance Requirements:
      a. Measuring range: 0 to 20 ppm.
      b. Accuracy: 1 percent of full scale:
         1) Within 2 ppm for valves above 1 ppm.
         2) Within 1 ppm for valves below 1 ppm.
      c. Repeatability: 0.1 ppm.
      d. Response time: 90 percent value in less than 60 seconds.
3. Element:
   a. Optical type that measures the fluorescence or luminescence of a ruthenium or platinum coated sensor.
   b. Using no membrane, electrodes, or electrolyte.
   c. Drift: less than 1 percent per year.
   d. Automatic self-diagnostics.
   e. Integral temperature sensor.
   f. Maximum pressure: 100 psi.
   g. Power supply: From transmitter through the sensor cable.
   h. Enclosure: NEMA 6.
   i. Provide automatic cleaning.

4. Transmitter:
   a. Power supply:
      1) 120 VAC.
      2) Power consumption: 75 VA maximum.
   b. Outputs:
      1) Isolated 4-20mA DC with HART communication protocol.
      2) Relay outputs:
         a) 3 Form-C contact.
         b) Rated 5 amps at 120 VAC.
         c) Programmable.
   c. Microprocessor based with features resident in non-volatile memory.
   d. Display dissolved oxygen content with 0.01 ppm resolution over a range of 0.00 to 3.99 ppm and 0.1 ppm resolution over a range of 4.0 to 20.0 ppm.
   e. Display temperature with 0.1 degree Celsius resolution.
   f. Enclosure rating: NEMA 4X.
   g. Automatic temperature compensation.

5. Components:
   a. Manufacturer cables for sensor to transmitter connection.

A. One of the following:


7. Or equal.

2.03 ACCESSORIES

A. Calibration Equipment:
   1. Provide components recommended by the manufacturer to verify calibration.

B. Provide sun shield for outdoor installations.

C. Provide complete Hach flow cell for probe mounting in enclosure:
   1. Accept water flow from sample pump at inlet pressure of 20 psig at 40 degrees Celsius.
   2. Inlet valve, pipe elbow, clamps, gaskets, and o rings for installation as provided by manufacture
   3. LDO flow cell body 7300300 series complete with top and bottom sections and all appurtenances as shown in manufacturer’s instruction sheet for LDO flow cell.
2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

B. Factory-calibrate each analyzer at a facility that is traceable to the National Institute of Standards and Technology (NIST).

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 (NOT USED)

3.02 (NOT USED)

3.03 INSTALLATION

A. Refer to Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. Refer to Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. Refer to Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

C. Furnish 4 hours of OWNER training.

3.08 PROTECTION
A. Refer to Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.

END OF SECTION
PART 1  GENERAL

1.01  SUMMARY

A. Section includes requirements for:
   1. RTD temperature instruments.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.

C. Provide all instruments identified in the Contract Documents.

1.02  REFERENCES

A. Refer to Section 17050.

1.03  DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. RTD - Resistance Temperature Detector.

1.04  SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Furnish complete Product Data, Shop Drawings, Test Reports, Operating Manuals,
   Record Drawings, Manufacturer’s certifications, Manufacturer’s Field Reports, and
   other submittals as specified in Section 17050, and below.

1.05  QUALITY ASSURANCE

A. Refer to Section 17050.
B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS
A. Refer to Section 17050.

1.08 WARRANTY
A. Refer to Section 17050.

1.09 MAINTENANCE
A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. One of the following or equal:
   1. Rosemount Model 3144P transmitter with Series 68 sensor.
   2. Acromag 1500 Series.
   3. Siemens SITRANS T.

2.02 MANUFACTURED UNITS
A. RTD's:
   1. General:
      a. Temperature measuring instrument shall include an RTD temperature element, transmitter, and thermowell.
   2. Performance requirements:
      a. Accuracy:
         1) Within 0.25 percent of calibrated span.
      b. Repeatability:
         1) 0.25 percent of full scale.
      c. Sensor lead wire compensation: maximum zero shift of 0.2 percent of the temperature range.
3. Element:
   a. 100-Ohm platinum thin film resistance temperature detector (RTD).
   b. 3-wire.
   c. Hermetically sealed, and enclosed in 316 stainless steel outer sheath.
   d. Single element temperature sensor shall be spring-loaded.
4. Transmitter:
   a. Microprocessor based.
   b. Compatible with 3-wire and 4-wire RTD inputs:
   c. Local Display:
      1) 5-digit LCD.
      2) Scaled in engineering units.
   d. Power supply:
      1) 24 VDC - loop powered.
      2) Power consumption: 15 VA maximum.
   e. Outputs:
      1) Isolated 4-20mA DC with HART communication protocol.
   f. Transmitter enclosure: NEMA 4X.
   g. Transmitter Mounting:
      1) As specified on the Instrument Data Sheets or Instrument Index.
      2) Connection to thermowell: 1/2-inch NPT.
      3) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Thermowell:
   1. Unless otherwise noted, provide thermowell with each RTD.
   2. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

B. Factory calibrate each temperature transmitter with 5-point calibration at a facility
   that is traceable to the National Institute of Standards and Technology.

C. Provide complete documentation covering the traceability of all calibration
   instruments.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has
   all necessary appurtenances including weld-o-lets, valves, etc. for proper
   installation of instruments.

C. Apply thermally conductive silicone grease to the sensor tip before insertion in
   thermowell.
3.02 FIELD QUALITY CONTROL
A. Refer to Section 17050.
B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING
A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING
A. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING
A. Refer to Section 17050.
B. Demonstrate performance of all instruments to the ENGINEER before commissioning.
C. Furnish 2 hours of OWNER training.

3.06 PROTECTION
A. Refer to Section 17050.

3.07 SCHEDULES
A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.
### A/E: Carollo Engineers

**TEMPERATURE TRANSMITTERS - RTD**

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**Project:**

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**Plant:**

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<td>Ambient Temperature</td>
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#### TRANSMITTER

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<tr>
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<td>8</td>
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<td>9</td>
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<td>Body Rating</td>
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#### TEMPERATURE ELEMENT

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<td>Mounting</td>
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<td>Connection</td>
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<td>Leads</td>
<td>Standard: Potted: Hermetically Sealed:</td>
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<td>Sheath Material</td>
<td>Stainless Steel</td>
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<td>22</td>
<td>Element Length</td>
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#### THERMOWELL

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<td>Type</td>
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<td>Material</td>
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<td>Insertion Length</td>
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<td>26</td>
<td>Process Connection</td>
<td>1/2-inch Thread: 3/4-inch Thread: Flange: Weld Mount:</td>
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#### OPTIONS

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**Notes:**

**END OF SECTION**
SECTION 17710

CONTROL SYSTEMS - PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
      a. Custom built instrumentation and control panels, including PCMs, RTUs, LCPs, Instrument Junction Boxes (IJBs), and Power Junction Boxes (PJBs).
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCP) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 16050 - General Requirements for Electrical Work.
      d. Section 16075 - Electrical Identification.
      e. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      f. Section 16422 - Motor Starters.
      g. Section 17050 - Process Control and Instrumentation Systems General Requirements.

1.02 REFERENCES

A. Refer to Section 17050.

B. Specific References:
   1. National Electrical Manufacturer’s Association (NEMA):
      a. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
      b. NEMA ICS 6 - Enclosures for Industrial Control and Systems.
   2. Underwriters Laboratories Inc. (UL):
      a. UL 50 - Enclosures for Electrical Equipment.
      b. UL 508 - Industrial Control Equipment.
      c. UL 508A - Standard for Industrial Control Panels.
1.03 DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 SYSTEM DESCRIPTION

A. Panel Dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or Manufacturer to design and size all panels:
      a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
      b. Panel sizes that substantially deviate (±3 inches in any dimension) from the sizes shown on the Drawings must be approved by the ENGINEER.
      c. Maximum panel depth: 30 inches, unless otherwise indicated.

B. Structural Design:
   1. Completed and installed panel work shall safely withstand seismic requirements at the project site indicated in Section 16050. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals in accordance with Sections 01330 and 17050.

B. Provide a control panel hardware submittal, for each control panel and enclosure being provided on this project, including but not limited to:
   1. Product Data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer’s literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop Drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by ENGINEER. The ENGINEER has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Provide installation details based on calculated shear and tension forces:
         1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
      b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
         1) Weight including panel internal components.
         2) Seismic forces and overturning moments.
         3) Shear and tension forces in connections.
      c. Cooling Calculations, to include but not limited to:
         1) Highest expected ambient temperature for the enclosure’s location.
2) Internal heat load.
3) Exposure to direct sunlight.
4) Dimensions of the enclosure in inches.
5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic Design:
   1. Seismic Panel Construction:
      a. Seismic Anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612:
         1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
      b. For floor mounted free standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements per Section 01612. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

A. Refer to Section 17050.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by Underwriters Laboratories to assemble and certify UL-labeled control panels:
   1. Provide all components and equipment with UL508 listing.
   2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL508A labeling:
   3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 17050.

B. Crate all panels for shipment using a heavy framework and skids:
   1. Provide factory-wrapped waterproof flexible barrier material for covering materials, where applicable, to protect against physical damage in transit.
   2. Provide suitable shipping stops and cushioning material for all instruments shipped with the panel to prevent damage due to mechanical shock during shipment.
   3. Provide each separate panel unit with removable lifting lugs to facilitate handling.

C. Ship all panels by dedicated air ride van, unless otherwise specified or approved.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.
B. Provide enclosures suitable for the location and environmental conditions in which they are located, and in the NEMA types in accordance with Section 16050, unless otherwise indicated.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. Refer to Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. As listed below in the individual component paragraphs.
   B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one Manufacturer.

2.02 EXISTING PRODUCTS
   A. Provide labor and materials for complete modifications to existing panels as required.

2.03 MATERIALS
   A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA 1: Steel.
      b. NEMA 4: Steel with gasketed door, rain tight.
      c. NEMA 4X: Stainless steel 316 (unless indicated 304 on the drawings)
      d. NEMA 4X: polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA 12: Steel with gasketed door, dust-tight.
      f. NEMA 7: Cast aluminum.
   B. Bolting Material:
      1. Commercial quality 1/2-inch diameter, stainless steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
      2. Carriage bolts for attaching end plates.
3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/Enclosures:
   1. Manufacturers: One of the following:
      a. Rittal.
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2 inch holes at 12 inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher level sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

<table>
<thead>
<tr>
<th>Enclosure Height (inches)</th>
<th>Minimum Enclosure Steel Thickness (gauge)</th>
<th>Minimum Back Mounting Panel Thickness (gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 57</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>57 - 69</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>69 - 82</td>
<td>12, except 10 on back</td>
<td>10</td>
</tr>
<tr>
<td>82 or more</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.

   c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

   d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

   e. Door construction:
      1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
      2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
      3) Heavy gauge piano type continuous stainless steel hinges.
      4) For NEMA 12, 4 and 4X, provide oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
      5) Gasket installed to seal against roll lip on the enclosure opening.

   f. Latches:
      1) For panels each door provided with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely,
forming a compressed seal between door and gasket, at the top, side, and bottom.

a) Provide padlock for each enclosure with padlock provisions.

2) Include an oil-tight key-locking, 3-point latching mechanism on each door:
   a) Provide 2 keys per panel.
   b) All locks keyed the same.

3) For large type NEMA 4 and NEMA 4X cabinets, not available with 3-point latching hardware, provide multiple clips and padlock hasps.

4) Provide quick release latches for all NEMA 4 and 4X enclosures.

g. Panel cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
   3) Reinforce around cut-outs with steel angles or flat bars for the following:
      a) Large panel cutouts; for example, openings for local operator interfaces.
      b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above the following requirements for NEMA 4X powder coated stainless steel enclosures apply:
   a. Minimum 14 gauge, Type 304
   b. Captive stainless steel cover screws threaded into sealed wells.
   c. Finish: white polyester powder coating.
   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.

4. Outdoor Panels. Supplementary requirements for panels located outdoors are as follows:
   a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
   b. Door hardware: stainless steel.
   c. Provide rain canopy and sun shield.
   d. Bases: Heavy channel, gasketed iron bases, flanges up, for anchoring to pad.

B. Arrangement of Components:
   1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
   2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the ENGINEER.
   4. All control panel mounted operator interface devices shall be mounted between 3 feet and 6 feet above finished floor.

C. Overcurrent Protection:
   1. Main overcurrent device:
a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120 VAC circuits:
   1) Door-mounted disconnect handles are not acceptable.
   2) Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
   3) Provide means to defeat the interlock.
b. Control panels supplied with 120 VAC:
   1) Provide an internal breaker with the line side terminals covered by a barrier.
   2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.

2. Provide circuit breakers in accordance with Section 16412.
3. Selection and ratings of protective devices:
   a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
   b. Voltage rating: Not less than the voltage of the application.
   c. Select current rating and trip characteristics to be suitable for:
      1) Maximum normal operating current.
      2) Inrush characteristics.
      3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120 VAC instrument installed within its respective control panel and clearly identified for function.
   b. An individual fuse for each PLC discrete output. Provide with individual fuse with blown fuse indication external of the I/O card:
      1) Size external fuse to open before any I/O card mounted fuses.
   c. An individual 5-ampere fuse for each discrete input loop.
   d. An individual 1/2-ampere loop for each 4-20mA analog loop powered from the control panel.
   e. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. Provide fuses rated for the voltage and available short circuit current at which they are applied.
   c. Provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings or as required for the application.
   d. Manufacturer: One of the following:
      1) Ferraz Shawmut.
      2) Littelfuse.
      3) Bussmann.
6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35mm rail.
      2) Touch safe design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown fuse indicator.
   b. Provide nameplate identifying each fuse:
      1) In accordance with Section 16075.
   c. Manufacturer: One of the following:
      1) Phoenix Contact.
      2) Allen Bradley 1492-FB Series B.

7. Control Circuit Breakers:
   a. DIN rail mounting on 35mm rail.
   c. Rated 250 VAC.
   d. Interrupting Rating: 10kA or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As indicated on the Drawings or as required for the application.
   f. Provide nameplate identifying each circuit breaker:
      1) In accordance with Section 16075.
   g. Manufacturer: One of the following:
      1) Phoenix Contact.
      2) ABB.
      3) Allen Bradley Series.
      4) Square D.

D. Conductors and Cables:
1. Power and Control Wiring:
   b. Insulation: 600V type MTW.
   c. Minimum Sizes:
      1) Primary power distribution: 12 AWG.
      2) Secondary power distribution: 14 AWG.
      3) Control: 16 AWG.
   d. Color:
      1) AC power (line and load): BLACK.
      2) AC power (neutral): WHITE.
      3) AC control: RED.
      4) DC power and control (ungrounded): BLUE.
      5) DC power and control (grounded): WHITE with BLUE stripe.
      6) Ground: GREEN.

2. Signal Cables:
   b. Insulation: 600V, PVC outer jacket.
   c. Minimum Size: 16 AWG paired triad.
   d. Overall aluminum shield (tape).
   e. Copper drain wire.
   f. Color:
      1) 2 Conductor:
         a) Positive (+): BLACK.
         b) Negative (-): WHITE, RED.
2) 3 Conductor:
   a) Positive (+): BLACK.
   b) Negative (-): RED.
   c) Signal: WHITE.

g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor Identification:
1. Identify all conductors and cables with wire markers in accordance with Section 16075.
2. Readily identified without twisting the conductor.

F. General Wiring Requirements:
1. Wiring Methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect and control power transformer. Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect cannot be closed until all doors are closed.
   a. Provide means to defeat this interlock.
4. Control panels supplied with 120 VAC:
   a. Provide an internal breaker with the line side terminals covered by a barrier.
   b. Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
5. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
6. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
7. Provide surge protection device on input supply power.
8. Provide nonmetallic ducts for routing and organization of conductors and cables:
   a. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
   b. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
      1) 120 VAC: Grey colored ducts.
      2) 24 VDC: White colored ducts.
9. Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:
   a. Screw-on cable tie mounts.
   b. Hammer-on cable tie mounting clips.
   c. Fingers of the nonmetallic duct.
10. The free ends of cable ties shall be cut flush after final adjustment and fastening.
11. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
12. Support panel conductors where necessary to keep them in place.
13. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
14. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
   a. Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Thermal Management:
   1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050.
   2. Air Conditioner:
      a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
      b. Provide filters on intake and exhaust openings.
      c. Increase panel sizes as needed to accommodate cooling units.
      d. Enclosure rating: NEMA 4X.
      e. Closed loop design.
      f. Power Supply: 120 VAC.
      g. Utilize a CFC-free refrigerant.
      h. Manufacturers: The following or approved equal:
         1) Kooltronic Integrity Series 21.
   3. Heating:
      a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:
         1) The panel is not supplied with 120 VAC power.
         2) There are no electronics or moisture-sensitive devices in the enclosure.
         3) The panel is smaller than 38 inches high.
   4. Heat Exchanger:
      a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
      b. Filterless design to facilitate easy cleaning of the core.
      c. Mounting: indicated on the Drawings.
   5. Enclosure Temperature Sensor:
      a. Provide wall mount RTD transmitter to measure internal cabinet temperature, in all enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
      b. Platinum RTD.
      c. 4-20 mA output.
      d. Sensor and electronic enclosure.
6. Enclosure Temperature Switch:
   a. Provide wall mount bitmetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
   b. Sensor and electronic enclosure.
   c. Accuracy: ±2.0 degrees Fahrenheit.
   d. Manufacturer: One of the following or approved equal:
      1) Hoffman ATEMNC.

7. Fan Ventilation:
   a. Provide Hoffman fan speed control:
      1) Automatically adjust fan speed depending on remote temperature sensor input.
      2) Field adjustable temperature sensitivity.
      3) Polycarbonate control housing.
      4) 120VAC 60Hz.
      5) NEMA 5-15R cord connections.
      6) [Mounting:
         a) Panel mount:
            (1) Mounting brackets.
         b) Rack mount:
            (1) Designed for fan cooling trays.
            (2) 1 RU rack space.]
      b. Muffin style:
         1) Provide two door/cabinet mounted vent fans for every 72 inches of cabinet width.
         2) Provide Finger Guard kit.
         3) Filter kit with 2 spare filters for each intake fan.
         4) Provide bezel and gasket kit.
      c. Temperature control switch and alarm:
         1) Power: 120VAC.
         2) Bimetallic temperature sensor.
         3) Adjustable setpoint range 30 degrees Fahrenheit to 140 degree Fahrenheit.
         4) Hoffman ATEM series or equal.

B. Panel Meters:
   1. Pointer Type:
      a. Suitable for panel mounting.
      b. Minimum scale length: 3-inches.
      c. Calibrated in engineering units.
      d. Accuracy: ±2 percent of span.
      e. NEMA 4/IP65 sealed front metal bezel.
      f. Manufacturer: One of the following:
         1) Yokogawa.
   2. Digital process indicators:
      a. General:
         1) Integral provisions for scaling.
         2) Scale to process engineering units.
3) Switch programmable decimal points.
4) NEMA 4/IP65 sealed front bezel.

b. Current and Voltage indicators:
   1) 3 1/2 - digit minimum.
   2) Minimum character height: 0.5 inches.
   3) Accuracy:
      a) AC/DC volts: ± (0.1 percent of reading + 2 digit).
      b) DC current: 4 - 20mA: ± (0.1 percent of reading + 1 digit).
      c) DC voltage: 0 - 10V: ± (0.1 percent of reading + 1 digit).

c. Operating voltage: 120 VAC.
d. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.
   1) Manufacturer: One of the following:
      a) Red Lion.
      b) Action Instruments Visipak.

3. Digital Bar Graph Meter:
   a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
   b. Suitable for panel mounting.
   c. LED display:
      1) Not less than 3 decimal digits.
      2) Not less than a 101 segment LED bar graph.
   d. Input signal:
      1) All conventional current loops and voltage control signals.
   e. Minimum sample rate of once per second.
   f. Provisions for field adjustable scaling and/or offset.
   g. Accuracy shall be ±1 least significant digit.
   h. Manufacturer: One of the following:
      1) Ametek Dixson.
      2) Yokogawa.
      3) Weschler Instruments.

4. Counters:
   a. 6 digits.
   b. Switch selectable inputs:
      1) Switch contacts.
      2) CMOS.
      3) TTL.
      4) Magnetic pickup.
      5) RLC sensors.
   c. Selectable up/down control via external signal.
   d. Remote reset.
   e. Remote Inhibit to prevent accumulating counts.
   f. Programmable to enable or disable front panel reset.
   g. Non-volatile memory to retain all data upon loss of supply power.
   h. Sunlight readable.
   i. Operating Temperature: 0 degrees Celsius to 50 degrees Celsius.
   j. Manufacturer: One of the following:
      1) Red Lion PAX Series.

C. Pilot Devices:
   1. General:
      a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
   1) 30.5mm.

c. Heavy duty.

d. Pushbuttons:
   1) Contacts rated:
      a) NEMA A600.
   2) Furnish one spare normally open and normally closed contact with each switch.

e. Selector switches:
   1) Contacts rated:
      a) NEMA A600.
      b) Knob type:
   2) Furnish one spare normally open contact and normally closed contact with each switch.
   3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.

f. Pilot lights:
   1) Type:
      a) LED for interior installations.
      b) Incandescent for exterior installations.
   2) Push to Test.
   3) Lamp Color:
      a) On/Running/Start: Red.
      b) Off/Stop: Green.
      c) Power: White.
      d) Alarm: Amber.
      e) Status or Normal Condition: White.
      f) Opened: Amber.
      g) Closed: Blue.
      h) Failure: Red.

2. Indoor and Outdoor Areas:
   a. NEMA type 4/13.
   b. Manufacturer: One of the following:
      1) Allen Bradley Type 800T.
      2) Square D Class 9001 Type K.
      3) General Electric Type CR104P.
      4) IDEC TWTD.

3. Corrosive Areas:
   a. NEMA 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
   d. Manufacturer: One of the following:
      1) Cutler Hammer Type E34.
      2) Square D Class 9001 Type SK.
      3) Allen Bradley Type 800H.
      4) IDEC TWTD.

4. Hazardous (Classified) Areas/Class I Division 2:
   a. NEMA 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc:
1) All contacts contained within a hermetically sealed chamber:
   a) Pushbuttons.
   b) Selector switches.
   c) Push-to-test contacts on pilot lights.
2) UL listed and labeled for Class I Division 2 areas.
   d) Manufacturer: One of the following:
      1) Cutler Hammer Type E34.
      2) Allen Bradley Type 800H.

D. Potentiometer and Slidewire Transmitters:
   1. Provide a DC output in proportion to a potentiometer input.
   2. Potentiometer input:
      a. 100 ohms to 100K ohms.
      b. Impedance ≥1M ohms.
      c. Zero Turn-Up: 80 percent of full scale input.
      d. Span Turn-Down: 80 percent of full scale input.
   3. Field configurable output:
      a. Voltage and Current: All conventional current loops and voltage control
         signals.
   4. Accuracy including linearity and hysteresis ±0.1 percent max at
      25 degrees Celsius.
   5. Operating temperature: 0 degrees Celsius to 55 degrees Celsius.
   6. Supply power: 9 to 30 VDC.
   7. Manufacturer: One of the following:
      a. Phoenix Contact.

E. Signal isolators and converters:
   1. Furnish signal isolators that provide complete isolation of input, output, and
      power input:
      a. Minimum isolation level: 1.5 kV AC/50 Hz for at least 1 minute.
      b. Adjustable span and zero.
      c. Accuracy: ±1.0 percent of span.
      d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
   2. Manufacturer: One of the following:
      a. Phoenix Contact MCR Series.
      b. Acromag 1500, 600T, 800T, Flat Pack or ACR Series.
      c. Action Instruments Q500 Series or Ultra SlimPakII.
      d. AGM electronics Model TA-4000.

F. Relays:
   1. General:
      a. For all types of 120 VAC relays, provide surge protection across the coil of
         each relay.
      b. For all types of 24 VDC relays, provide a free-wheeling diode across the
         coil of each relay.
   2. General Purpose:
      a. Magnetic control relays.
      b. NEMA A300 rated:
         1) 300 Volts.
         2) 10 Amps continuous.
         3) 7,200 VA make.
         4) 720 VA break.
c. Plug-in type.
d. LED indication for relay energized.
e. Coil voltages: As required for the application.
f. Minimum poles: 2PDT.
g. Touch safe design: All connection terminals to be protected against accidental touch.
h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as shown on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (slave/interposing) relays when the following occurs:
   1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
   2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35mm rail.
m. Ice Cube type relays with retainer clips to secure relay in socket.
n. Integrated label holder for device labeling.
o. Manufacturer: One of the following:
   1) Phoenix Contact PLC series.
   2) Potter and Brumfield Type KRP or KUP.
   4) Allen Bradley Type 700 H Series.
   5) Square D Type K.

3. Latching:
   a. Magnetic latching control relays.
   b. NEMA B300 rated:
      1) 300 Volts.
      2) 10 Amps continuos.
      3) 3,600 VA make.
      4) 320 VA break.
   c. Plug-in type.
   d. DIN rail mounting on 35mm rail.
   e. Coil voltage: as required for the application.
   f. Minimum poles: 2PDT; as required for the application. Plus 1 spare pole.
   g. Touch safe design: All connection terminals to be protected against accidental touch.
   h. Clear cover for visual inspection.
   i. Provide retainer clip to secure relay in socket.
   j. Manufacturer: One of the following, or equal:
      1) Square D type 8501 Type K.
      2) IDEC TWTD.

4. Time Delay:
   a. Provide time delay relays to control contact transition time.
   b. Contact rating:
      1) 240 Volts.
      2) 10 Amps continuos.
      3) 3,600 VA make.
      4) 360 VA break.
   c. Coil voltage: as required for the application.
   d. Provide Pneumatic or Electronic type with on-delay, off-delay, and on/off delay:
1) For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.

   e. Minimum poles: 2PDT.
   f. Units include adjustable dial with graduated scale covering the time range in each case.
   g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
   h. Manufacturer: One of the following:
      1) Idec GT3 series.
      2) Agastat type Series 7000 series (pneumatic).
      3) Allen Bradley type 700HR Series.

G. Terminal blocks:
   1. Din rail mounting on 35mm rail.
   2. Suitable for specified AWG wire.
   3. Rated for 30 amperes at 600 Volts.
   4. Screw terminal type.
   5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
   6. Finger safe protection for all terminals for conductors.
   7. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degree Celsius to 105 degrees Celsius.
   8. Terminals: Plainly identified to correspond with markings on the diagrams:
      a. Permanent machine printed terminal identification.
   9. Disconnect type field signal conductor terminals with socket/screw for testing.
   10. Identify terminals suitable for use with more than 1 conductor.
   11. Position:
      a. So that the internal and external wiring does not cross.
      b. To provide unobstructed access to the terminals and their conductors.
   13. Manufacturer: One of the following:
      a. Phoenix Contact UK5 Series.
      b. Allen Bradley Series 1492.
   14. Wire duct:
      a. Provide flame retardant plastic wiring duct, slotted with dust cover.
      b. Type:
         1) Wide slot.
         2) Narrow slot.
         3) Round hole.
      c. Manufacturer: One of the following:
         1) Panduit.

H. Surge Protection Devices:
   1. Provide Surge Protection Device ( SPD) for Power Entrances:
      a. Nominal 120 VAC with a nominal clamping voltage of 200 Volts.
      b. Non-faulting and non-interrupting design.
      c. A response time of not more than 5 nanoseconds.
   2. Control Panel Power System Level Protection, non-UPS powered:
a. Design to withstand a maximum 10 kA test current of a 8/20µs waveform according to ANSI/IEEE C62.41.1-2002 Category C Area.
b. Provide both normal mode noise protection (between current carrying conductors) and common mode (between current carrying conductor and neutral) surge protection.
c. DIN rail mounting.
d. Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
   1) Gas-tight connections.
   2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
e. Visual status indication of MOV status on the input and output circuits.
f. Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
g. Meeting the following requirements:
   1) Response time: ≤100 ns.
   2) Attenuation: ≥ -40dB at 100 kHz as determined by a standard 50 ohms insertion test.
   3) Safety approvals:
      a) UL 1283 (EMI/RFI Filter).
      b) UL 1449 2nd Edition.
h. Manufacturer: One of the following:
   1) Phoenix Contact type SFP TVSS/Filter.
   2) Liebert Accuvar series.
   3) Istatrol.

3. Data and Signal Line Protectors – Panel Mounted:
   b. DIN rail mounting on 35mm rail (except field mounted SPDs).
   c. SPD’s consisting of 2 parts:
      1) A base terminal block.
      2) A plug protection module:
         a) Replacing a plug does not require the removal of any wires nor interrupt the signal.
         b) Base and plug coded to accept only the correct voltage plug.
   d. SPD Manufacturer: One of the following:
      1) Phoenix Contact Plugtrab Series.
      2) Bournes Series 1800.

4. Data and Signal Line Protectors – Field Mounted:
   b. Manufacturer: One of the following:
      1) Phoenix Contact Pipetrab.
      2) Joslyn JMD Series.

I. Beacons:
   1. Manufacturer:
      a. One of the following, or equal:
         1) Federal Signal Corp Starfire Series.
         2) Allen Bradley 855 B *-* 10 Series.
J. Power supplies:
1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24 volt DC or other DC voltages required or as required for the application.
3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
   a. Provide Automatic switchover upon module failure.
   b. Alarm contacts monitored by the PLC.
5. Sized to provide 40 percent excess rated capacity.
6. UL508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output regulation: ±0.05 percent for a 10 percent line change or a 50 percent load change:
   a. With remote voltage sensing.
10. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
11. Touch safe design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35mm rail.
14. Manufacturer: One of the following:
   a. Phoenix Contact Quint series.
   b. IDEC PS5R series.
   c. Sola.
   d. Acopian.

K. Starters:
1. Magnetic Motor Starters:
   a. In conformance with the requirements of Section 16422.
2. Integral Self-Protected Starters:
   a. In conformance with the requirements of Section 16422.

L. Limit Switches:
1. NEMA-4X.
2. AC contact rating 120V, 10A.
3. DC contact rating 125V, 0.4A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating Temperature Range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
9. Manufacturer:
   a. Allen Bradley 802.
   b. Honeywell HDLS.
   c. Omron D4.
e. ABB equal.

M. Intrusion/Tamper Switches:
1. Manufacturer: One of the following or equal:
   a. Sentrol Industrial – Magnetic Type.
   b. Allen-Bradley – Limit Switch Type.
2. Feature and Characteristic (magnetic type):
   a. The configuration of the magnetic actuator and intrusion switch shall be suitable for the installation as indicated in the Drawings.
   d. Response Time: 10 msec.
   e. Life Cycle: 100,000 Under Full Load.
   f. Load Rating: 150 VA.
   g. Use on indoor locations.
   h. Switching Voltage: 120 VAC.
3. Feature and Characteristic (limit type):
   a. Provide with roller and adjustable deadband.
   b. AB Class 801 or equivalent.
   c. Use on panels and outdoor locations where deadband is necessary to avoid false alarm from wind.

2.07 ACCESSORIES

A. Refer to Section 17050.

B. Provide panels with an inside protective pocket to hold the panel Drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15 inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:
   1. Provide in accordance with Section 16075 on all internal and external instruments and devices.
   2. Provide a nameplate with the following markings that is plainly visible after installation:
      a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
      b. Supply voltage, phase, frequency, and full-load current.
      c. Short-circuit current rating of the panel based on one of the following:
         1) Short-circuit current rating of a listed and labeled assembly.
         2) Short-circuit current rating established utilizing an approved method.
   3. Provide enclosures with a flange mounted disconnect that is interlocked with the doors.
F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:
   1. Safety plate glass.
   2. Secured by rubber locking seal.
   3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Lighting:
   1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
      a. Covered or guarded.
      c. Provide 18-watt fluorescent lamp for indoor enclosures less than 30 inches wide.
      d. Provide 40-watt fluorescent lamp for enclosures larger than 30 inches wide:
         1) Provide additional fixtures for every 36 inches of width.
      e. Provide 40 watt incandescent lamp for exterior enclosures:
         1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:
   1. Provide one duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 125-volt, single-phase, 15-ampere.

I. Grounding:
   1. Provide the following:
      a. Grounding strap between enclosure doors and the enclosure.
      b. Equipment grounding conductor terminals.
      c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
      d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
   2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND” or the letter “G,” or the color green.
   3. Signal (24 VDC) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
   4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
   5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
   6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
   7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
   8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.
   9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
   10. Bond together all PLC or RTU racks (remote or local) processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit.
2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:
   1. Metallic (Non-Stainless):
      a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer’s recommendations to achieve a smooth, well-finished surface.
      b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer’s recommended dry film thickness, and allowed to dry before applying the finish coat.
      c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
      d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
   2. Stainless Steel:
      a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
   1. Exterior color of panels mounted indoors shall be manufacturer’s standard light gray.
   2. Exterior of panels mounted outdoors shall be manufacturer’s standard white.
   3. Panel interiors shall be manufacturer’s standard white.

2.11 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within ±1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.

D. Provide 3-1/2 inch high concrete housekeeping pads for free-standing enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
1. Undercoat floor mounted panels.

F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the CONTRACTOR.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Refer to Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. Refer to Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. Refer to Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 17712

CONTROL SYSTEMS - UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1  GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 16050 - General Requirements for Electrical Work.
      d. Section 17050 - Process Control and Instrumentation Systems General Requirements.

1.02 REFERENCES

A. Refer to Sections 16050 and 17050.

B. Federal Communications Commission:
   1. FCC Part 15, Class A.
   2. FCC Part 15, Class B.

C. Underwriters Laboratories, Inc. (UL):

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA PE1 - Uninterruptible Power Systems Specification and Performance Verification.

E. Institute of Electrical and Electronic Engineers (IEEE):
F. American National Standards Institute:

G. International Organization for Standardization (ISO):
   1. ISO 9001.

1.03 DEFINITIONS

A. Refer to Sections 16050 and 17050.

B. Specific Definitions:
   1. Critical Load: load supplied by the UPS.
   2. MOV: Metal Oxide Varistor.

1.04 SYSTEM DESCRIPTION

A. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Product Data:
   1. Manufacturer and model number.
   2. Catalog Data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Ratings:
      a. Input voltage.
      b. Output voltage.
      c. Input/output power factor.
      d. Efficiency.
      e. Harmonic distortion.
      f. Runtime.
   5. Noise specifications.
   7. Warranties and Maintenance Contracts:
      a. Documentation to demonstrate conformance to specifications noted herein.
   8. All communications requirements such as software, cards, etc.
   9. Alarms and status available for remote monitoring and system health.

C. Shop Drawings:
   1. Power distribution block diagrams.
   2. Front and rear views of equipment enclosures:
      a. Front elevation including all control and indicating devices.
   3. Support points and weight of overall equipment.
   4. Schematic and control wiring diagrams including, but not limited to:
      a. Line and load terminals.
b. Alarm and status terminals.
c. External wiring requirements for all communication signals.

5. Switching and overcurrent protective devices.

D. Calculations:
1. Include derating for temperature and elevation as necessary.
2. UPS sizing computation:
   a. Apply safety factors as specified herein.
   b. Provide itemized list of critical loads, including individual VA and Watt ratings.
3. Battery time calculation based on specified runtime.
4. Total battery recharge time as a function of capacity utilized.

E. Design Data:
1. Design mounting and anchorage for seismic design criteria specified in Section 01612:
   a. Provide seismic kits as required to meet design criteria.

F. Record Documents:
1. Provide record drawings of installed unit(s) including layout and wiring.

G. Manufacturer’s Field Reports.

H. Operation and Maintenance Manuals:
1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
2. Recommendations for maintenance procedures and intervals.
4. Parts list.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications:
1. A minimum of 10 years experience in the design, manufacture, and testing of solid-state UPS systems.
2. ISO 9001 certified.

B. Regulatory Requirements for complete UPS system:
1. UL listed per UL Standard 1778
2. IEEE C62.41, Categories A & B.
3. FCC 15:
   a. Greater than 2000 VA - Class A.
   b. Less than 2000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.
1.09 WARRANTY

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double-conversion true-online UPS manufacturers, one of the following:
   1. Free-standing UPS, 700-3000 VA:
      a. Emerson Network Power - Liebert GXT 2U (700 - 3000 VA).
      b. Eaton Corporation - Powerware 9120 (700 - 3000 VA).
   2. Rack-mounted UPS, 700-3000 VA:
      a. Emerson Network Power - Liebert GXT 2U (700 - 3000 VA).
      b. Eaton Corporation - Powerware 9125 RM (700 - 3000 VA).

2.02 MANUFACTURED UNITS

A. Double conversion true on-line UPS system requirements:
   1. System characteristics:
      a. Provide freestanding UPS as specified and as indicated on the Drawings.
      b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
      c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
      d. Efficiency greater than 85 percent AC-AC, all modes.
      e. Acoustical Noise:
         1) Less than 55 dBA at 5 feet.
      f. Output connections:
         1) Receptacles:
            a) 700-2500 VA units:
               (1) Provide a minimum of four NEMA 5-15R or 5-20R receptacles.
         2) Provide hardwired connections as indicated on the Drawings.
      g. Protection:
         1) Undervoltage:
            a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
         2) Overvoltage:
            a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
         3) Overcurrent:
            a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.
         4) Surge Protection:
            a) MOV-based.
   2. Electrical Characteristics:
      a. AC Input:
         1) Single phase.
         2) Voltage as indicated in the UPS schedule.
a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
b) 120V input:
   (1) 2-wire plus ground
c) 208/120V or 240/120 input:
   (1) 3-wire plus ground.
3) Current:
   a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
4) Frequency range of operation:
   a) 57-63 Hz.
5) Power factor:
   a) Not less than 0.95 lagging at rated load.
b. AC Output:
   1) Single Phase.
   2) Voltage:
      a) Regulation:
         (1) ±3 percent for 3000 VA rating and below.
         (2) ±5 percent for greater than 3000 VA rating - static load.
         (3) ±10 percent for greater than 3000 VA rating - dynamic load.
b) Total Harmonic Distortion (THD) when operating on incoming power:
   (1) Not more than 3 percent for linear loads with a crest factor of 3:1.
   (2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.
c) Transient Response:
   (1) ±7 percent for a 20-100 percent step load.
   (2) Transient recovery time to nominal voltage within 90 milliseconds.
3) Load power factor:
   a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.
4) Frequency regulation:
   a) Within ±3.5 Hz when on utility power.
   b) Within ±1.0 Hz when on UPS power.
3. Environmental Requirements:
   a. Operating Ambient Temperature:
      1) UPS Module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
      2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).
b. Operating Altitude:
   1) Refer to Sections 16050 and 17050 for project site conditions.
4. System Components:
   a. Surge protective devices:
      1) MOV-supplied protection.
b. Inverter:
   1) Pulse-width modulated AC output signal.
   2) Overload withstand minimum time without transferring to bypass:
      a) 101 to 110 percent for 2 minutes.
      b) 111 to 125 percent for 10 seconds.
c) 126 to 150 percent for 1 second.
d) Greater than 150 percent for 96 milliseconds.
3) Transfer load to bypass when overload capacity is exceeded.
c. Battery Rectifier/charger:
1) Recharge batteries to 90 percent in 6 hours or less.
d. Batteries:
1) VRLA (Valve regulated lead acid), sealed, maintenance free.
2) Minimum 3-year float service life at 25 degrees Celsius.
3) Integral to UPS enclosure or housed in a matching enclosure.
4) Less than and including 6000 VA: hot-swappable.
5) Automatically perform routine battery health monitoring and provide
to

visual, audible, and/or serial warnings if abnormal battery conditions exist.
e. Automatic bypass switch:
1) Integral to UPS system.
2) Sense UPS overload, inverter failure, or overtemperature, and
   automatically transfer loads to source power.
3) Maximum detect and transfer time of 4-6 milliseconds.
4) Automatic re-transfer without power interruption to critical load.
5) Input shall match output in phase, voltage, frequency, and grounding.
6) Rated to carry the full input current of the UPS.
7) Provide ability for manual operation.
f. Manual maintenance bypass switch:
1) Provides isolation of the UPS for maintenance purposes.
2) Make-before-break design so that UPS can be isolated from the
critical loads by placing these loads on source power without
interruption of operation.
3) Utility and UPS status indications.
4) Supply necessary input/output cords and receptacles for connections
   with power source and UPS.
5) Transfer time less than 6 milliseconds.
6) Rated to carry the full input current of the UPS.
7) Standalone UL-listed.
8) Input match output in phase, voltage, frequency, and grounding.
9) UPS input connection and UPS output plug:
   a) 700 to 3000 VA units: NEMA receptacle and plug to match UPS
      connections.
   b) Above 3000 VA units: NEMA receptacle and plug or hardwiring
      to match UPS connections.
10) Utility and load connections:
    a) As indicated on the Drawings.
11) 700 to 3000 VA units - one of the following [or equal]:
    a) Liebert Micropod 2U.
    b) Powerware Powerpass 9125.
12) Above 3000 VA units - by manufacturer of UPS, with connections
    matched for operation with UPS.
g. UPS Chassis:
1) Electrically isolate from AC output neutral.
2) Include an equipment ground terminal.
h. Cooling:
1) Forced air cooled.
i. Locally displayed system indicators:
   1) Audible alarms during abnormal conditions:
      a) UPS fault or overload condition.
      b) Battery On.
      c) Low battery.
      d) Automatic Bypass On/Off.
      e) Input Power On.
      f) Battery testing mode.

j. Controls:
   1) Front-panel pushbuttons:
      a) UPS start-up, shutdown, and manual bypass (for automatic
         bypass).
      b) Testing.
      c) Visual/audible alarms reset.
   2) Applicable controls as specified in Communications Requirements.

k. Alarm contacts:
   1) Provide relay interface card and required interposing relays for 120
      VAC discrete input status signals:
      a) Low Battery.
      b) UPS Alarm.
      c) On UPS Power.

l. Communications Requirements:
   1) RS-232.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS
   input.

3.02 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation per drawings and specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.
   7. Check power and control wiring for tightness.
   8. Check terminal connectors for tightness.
   9. Assure connection and voltage of the battery string(s).

3.03 CLEANING

A. Refer to Section 17050.
3.04 PROTECTION

A. Refer to Section 17050.

3.05 SCHEDULES

A. Provide UPS for panels as indicated on the Drawings or listed below:
   1. PLC panel at Outfall Pump Station.
   2. RTU panel at Outfall Pump Station.
   3. RTU panel at Standpipe.

END OF SECTION
SECTION 17720

CONTROL SYSTEMS – PROGRAMMABLE LOGIC CONTROLLERS HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Programmable Logic Controller (PLC) based control systems hardware.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.
      c. Section 17710 - Control System - Panels, Enclosures, and Panel
         Components.
      d. Section 17733 - Network Materials and Equipment.
      e. Section 17761 - PLC Programming Software.
      f. Section 17762 - Control Systems SCADA Software.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. CPU: Central Processing Unit.
   2. I/O: Input/Output.

1.04 SYSTEM DESCRIPTION

A. Provide all PLC hardware as indicated on the Drawings and in this specification.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.
B. Product Data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.
      d. Internal processor battery back-up time.
   2. I/O Modules:
      a. Type.
      b. Standard wiring diagram.

C. Calculations:
   1. Submit calculations or documented estimate to verify that memory
      requirements of this Section are met, including spare requirements. If possible,
      use PLC manufacturer's calculation or estimating worksheet.
   2. Submit calculations to verify that spare I/O requirements of this Section are
      met.
   3. Submit calculations to verify that PLC power supply requirements of this
      Section are met.

1.06 QUALITY ASSURANCE

A. Provide PLC hardware manufactured at facilities certified to the quality standards of
   ISO Standard 9001 - Quality Systems - Model for Quality Assurance in
   Design/Development, Production, Installation, and Servicing.

B. Additional Requirements:
   1. Provide PLC system components by a single Manufacturer:
      a. Third-party communication modules may be used only for communication
         or network media functions not provided by the PLC manufacturer.
   2. Use PLC Manufacturer approved hardware, such as cable, mounting
      hardware, connectors, enclosures, racks, communication cable, splitters,
      terminators, and taps.
   3. All PLC hardware, CPUs, I/O devices, and communication devices shall be
      new, free from defects and produced by Manufacturers regularly engaged in
      the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.09 WARRANTY

A. Refer to Section 17050.

1.10 MAINTENANCE

A. Refer to Section 17050.
B. Installed Spare Requirements:
   1. I/O Points:
      a. 25 percent spare capacity for each type of I/O signal at each PLC or RIO. Calculate the spare capacity as the number of unused points on I/O modules for the given I/O type divided by the total number of points on existing I/O modules for given I/O type.
      b. Wire all spare I/O points to field terminal blocks in the PCM.
      c. Space shall be available in each PLC or RIO enclosure to support the future addition of 100 percent additional spare I/O.
   2. PLC Backplane Capacity:
      a. 25 percent or 3 spare backplane slots, whichever is greater.
   3. PLC Memory:
      a. 50 percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Allen-Bradley SLC 5/05.
   2. No substitution permitted.

2.02 MANUFACTURED UNITS

A. Programmable Logic Controller:
   1. Construction:
      a. Furnish plug-in modular system.
      b. Chassis wired logic is not acceptable.
      c. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
         1) Temperature: 0 – 55 degrees Celsius.
         2) RFI: 80 - 1000 MHz.
         3) Vibration: 10 - 500 Hz.
         4) Humidity: 0 - 95 percent.
      d. Provide internal power supplies designed to protect against over voltage and frequency distortion characteristics frequently encountered with the local power utility.
      e. Design the PLC system to function as a stand-alone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based Operator Interfaces:
         1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
   2. Components General:
      a. Provide each PLC with the functionality required to implement the control strategies and database shown and specified in the Contract Documents.
      b. Furnish each PLC with floating point math and PID controller modulating algorithms.
      c. Provide each CPU with internal fault analysis incorporating a fail-safe mode and a dry contact output for remote location alarming, as well as a local indicator on the PLC frame in the event of a fault in the PLC.
3. Central Processing Unit:
   a. Configure each central processor unit so that it contain all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
   b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements including the spare and expansion requirements.
   c. Capable of supporting and implementing closed loop floating-point math and PID control that is directly integrated into the CPU control program.
   d. Design the power supply to contain capacitors to provide for orderly shutdown in the event the incoming power does not meet specifications:
      1) Cease operation under this condition and force all outputs Off.

4. Memory:
   a. Non-volatile memory: On-Board Complementary Metal Oxide Semi-Conductor (CMOS), electrically erasable programmable read only memory, EEPROM, PCMCIA, Compact Flash card, or SD card.
   b. Supply with an internal lithium battery to retain non-volatile memory during power outages of up to 30 days. Battery to retain charge for minimum 1 year during normal operations.
   c. Furnish with an indicator showing the status of the batteries on the OIS graphic screen to alarm the operator that the batteries should be changed.
   d. Supply with sufficient memory to implement the specified control functions plus a reserve capacity in accordance with the requirements of this Section:
      1) This reserve capacity:
         a) Totally free from any system use.
      2) Programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.

5. Programming:
   a. Provide a system where processors are programmed by:
      1) Portable laptop computer both locally and via the PLC data network.

6. PLC Power Supply:
   a. Input: 120 VAC.
   c. Provide each PLC power supply sized to meet the following requirements:
      1) 120 VAC RMS plus or minus 15 percent, continuously.
      2) 120 VAC RMS plus or minus 30 percent, maximum 30 seconds.
      3) 120 VAC RMS plus or minus 100 percent, maximum 17 milliseconds.
      4) Line spikes at 1000 VAC:
         a) 5000 microseconds duration.
         b) 0.05 percent maximum duty cycle.
   d. Mounted in the PLC housing.
   e. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.

7. PLC Input/Output, I/O Modules:
   a. General:
      1) Compatible with all of the PLCs being furnished under the contract and by the same Manufacturer as the PLCs.
      2) Provide I/O modules that:
a) Isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
c) Accept dual ended inputs.

3) The commoning of grounds between I/O points is not acceptable.

4) Modules that are removable without having to disconnect wiring from the module's terminals:
   a) Utilize a swing-arm or plug-in wiring connector.

5) Provide at each PLC location the I/O modules required to provide the I/O points, including designated future I/O points, contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies:
   a) Provide at each PLC location an installed spare capacity in accordance with the requirements of this Section.
   b) Wire all spares provided to the field terminal strip.

6) Condition, filter, and check input signals for instrument limit conditions.

7) Filter, scale, and linearize the raw signal into an engineering units based measurement.

8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.

9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.

b. Discrete Input Modules:
   1) Defined as contact closure inputs from devices external to the input module.
   2) Provide inputs that are optically isolated from low energy common mode transients to 1500 volts peak from users wiring or other I/O Modules.
   3) Individually isolated inputs.
   4) With LED's to indicate status of each discrete input.
   5) Input signal level: 120 VAC and 24 VDC as indicated on the Drawings.
   6) Provide input module points that are individually fused with blown fuse indicator lights, mounted external of the module on the output terminal strip:
      a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.

c. Discrete Output Modules:
   1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
      a) Triac outputs may be used, with the permission of the ENGINEER, care must be used in applying this type of modules to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
   2) Optically isolated from inductively generated, normal mode and low energy, common mode transients to 1500 volts peak.
   3) LED's to indicate status of each output point.
   4) Each output point: Individually isolated.
d. Analog Input Modules:
   1) Signal Type: 4 to 20 mA DC. Analog to digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
   2) The analog to digital conversion updated with each scan of the processor. Individually isolated each input. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip:
      a) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.

e. Analog Output Modules:
   1) Signal Type: 4 to 20 mA DC
   2) Individual isolated output points each rated for loads of up to 1200 Ohms.

8. Communications Modules:
   a. Remote I/O Adapter Module:
      1) For any PLC location requiring more than one housing to mount all of the I/O modules, or is identified as an RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
      2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
      3) Provide adapter modules that supports all available types of I/O modules required.
      4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
      5) Complete diagnostic LEDs.
   b. Network Communications Modules:
      1) Ethernet:
         a) Included on Processor Module
         b) Ports: 1 RJ-45.
         c) Communication Rate: 10/100 Mbit/s.
      2) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

9. PLC Housing:
   a. Mount the PLC power supply, CPU, rack, and I/O modules in a suitable standard PLC backplane or housing.
   b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
   c. Provide blank slot filler module for each spare slot.

B. Programming:
   1. Refer to Section 17761.

C. Remote Inputs and Outputs (RIO's):
   1. Compatible with all of the PLCs being furnished under this Contract and shall be by the same Manufacturer as the PLCs and as a minimum includes:
      a. Power supply.
      b. Rack.
      c. Backplane.
      d. Communications module.
      e. I/O modules.
f. Enclosure.
2. Provide all cables and software needed for a complete and operational RIO system as shown in the Contract Documents.
3. House the RIO system in enclosures specified in Section 17710 and consistent with the area classifications as specified in Division 16.
4. Power to the RIO modules shall be provided by the enclosure’s power supplies, which shall be powered from its associated PCM.
5. The RIO communications modules for each RIO system shall have diagnostic LEDs.
6. Provide a group of preassigned diagnostic registers to report RIO system faults to the driver PLC.
7. The control system must continue operation should a fault occur on a single RIO drop:
   a. Upon clearing the fault, restart communications to that drop automatically.

2.03 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. Utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050.

3.03 CLEANING

A. Refer to Section 17050.

3.04 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Tailor training specifically for this project that reflects the entire control system installation and configuration.

C. Perform training by pre-approved and qualified representatives of the ICSC and or Manufacturer of the PLC hardware:
1. A representative of the ICSC may perform the training only if the representative has completed the Manufacturer's training course for the PLC hardware.

3.05 PROTECTION

A. Refer to Section 17050.

END OF SECTION
SECTION 17721

CONTROL SYSTEMS – HUMAN MACHINE INTERFACE HARDWARE

PART 1   GENERAL

1.01 SUMMARY
A. Section Includes requirements for:
   1. Human machine interface (HMI) control systems hardware.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as
      binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the
      Work of subcontractors, suppliers, and other individuals or entities performing
      or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This
      list of Related Sections is provided for convenience only and is not intended to
      excuse or otherwise diminish the duty of the CONTRACTOR to see that the
      completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General
         Requirements.
      c. Section 17712 - Control Systems - Uninterruptible Power Supplies 10
         KVA and Below.
      d. Section 17730 - SCADA Computer Equipment.
      e. Section 17762 - Control Systems SCADA Software.
      f. Section 17765 - Human Machine Interface Software.

1.02 REFERENCES
A. Refer to Section 17050.

1.03 DEFINITIONS
A. Refer to Section 17050.

1.04 SYSTEM DESCRIPTION
A. Provide all HMI hardware as identified in the Contract Documents.

1.05 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Product Data:
   1. Complete Manufacturer’s brochures for each item of equipment.
   2. Manufacturer’s operation and installation instructions.
   3. Additional requirements:
      a. Display type and size.
b. Operator input.
c. Processor type and speed.
d. Memory size.
e. Programming protocols.
f. Communication protocols.
g. Power requirements.
h. Operating temperature and humidity ranges. NEMA ratings.

C. Shop drawings:
   1. At a minimum, furnish the following:
      a. System block diagram showing relationship and connections between
devices provided. Include Manufacturer and model information, and
address settings.
      b. Mounting drawings with dimensions and elevations for each equipment
location, including identification of all components, preparation and finish
data, and nameplates.
      c. Electrical connection diagrams.
      d. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product
brochure or bulletin:
      a. Manufacturer’s model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials identified by each cabinet. Include with
each bill of material item the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Operation and Maintenance Manuals:
   1. Complete installation, operations, calibration, and testing manuals as
described in Section 17050.

E. Record Documents:
   1. Electrical connection diagrams revised to reflect any changes made in the field
and submitted as record Drawings.

1.06 QUALITY ASSURANCE

A. Additional Requirements:
   1. Use HMI manufacturer approved hardware, such as cable, mounting
hardware, connectors, enclosures, communication cable, splitters, terminators,
and taps.
   2. Provide hardware that is new, free from defects, of first quality, and produced
by Manufacturers regularly engaged in the manufacture of HMI products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.
1.09 WARRANTY

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. Automation Direct EA7-T15C.
   2. No Substitution Permitted.

2.02 MANUFACTURED UNITS

A. Human Machine Interface:
   1. General:
      a. Provide Human Machine Interfaces located on the face of the PLC panel at the Outfall Pump Station as indicated on the Drawings.
      b. NEMA 4 rated.
      c. Human Machine Interface consists of graphical display screen with operator input capabilities.
      d. Capable of stand-alone operation in conjunction with 1 PLC or RTU.
      e. Equipped with data network communication capabilities.
   2. Display:
      a. Type: Color, TFT LCD screen.
      b. Resolution: 1024 by 768 pixels.
      c. Size: 15.0 inches.
      d. Easy display viewing at any angle in various ambient light conditions.
      e. Operator Input: Configurable touch screen.
   3. Features and characteristics:
      a. Color Scale: 65,536 colors
      b. Display brightness: 220 NITS
      c. Backlit average lifetime: 50,000 hours
      d. Touchpad type: Analog resistive, 12 bit resolution
      e. Processor: 32 bit RISC CPU, 400 MHz, Plus Graphic Accelerator Chip
      f. System memory: SDRAM 64 Mbytes
      g. Flash memory: 64 Mbytes
      h. Logging Data Memory: Compact Flash Card, EA-CF-Card
      i. Number of screens: Up to 999
      j. Realtime clock: Built-in, battery backed up
      k. Ports: Serial, Type A and Type USB, Ethernet 10/100 Base-T
      l. Compact Flash Card & Card Slot: Provided for backup
      m. Supply power: 24 VDC
      n. Power consumption: 33 Watts
      o. Operating temperature: 0 – 50 degrees C
      p. Humidity: 10 to 85%, noncondensing
      q. Noise immunity: 1000 volts peak to peak, 1 microsecond pulse width, 1 nanosecond rise time
      r. Approvals: UL, Carollo Engineers.
2.03 ACCESSORIES
   A. Human Machine Interface Programming Software:
      1. Refer to Section 17765.
   B. Uninterruptible Power Supply (UPS):
      1. In accordance with Section 17712.
      2. Power the HMI from the UPS at the associated panel.
   C. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL
   A. Refer to Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION
   A. Refer to Section 17050.

3.02 FIELD QUALITY CONTROL
   A. Refer to Section 17050.

3.03 CLEANING
   A. Refer to Section 17050.

3.04 DEMONSTRATION AND TRAINING
   A. Refer to Section 17050.

3.05 SCHEDULES
   A. Provide HMI at Outfall Pump Station as indicated on the Drawings.

END OF SECTION
SECTION 17750
WIRELESS COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Radio Telemetry Units.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. CPM: Critical Path Method.
   2. EIRP: Effective Isotropically Radiated Power.
   3. Fade Margin: This is the amount of margin left to allow for the natural variations in radio performance, which will occur due to weather, air density, etc.
   5. ITS - Institute for telecommunications Science.

1.04 SYSTEM DESCRIPTION

A. Radios and antennas used on this project will be provided by OWNER

B. CONTRACTOR shall provided antenna poles, antenna ground rod and grounding, surge and lightning protection, as indicated on the Drawings.

C. If Add Alternate 1 is selected by the OWNER, CONTRACTOR shall:
1. Provide 50 foot high antenna tower and base as described in this Section.
2. Provide installation of tower at WRF as directed by Engineer.
3. Provide all appurtenances to install tower including, but not limited to, base as recommended by manufacturer, and grounding as shown on the Drawings.
4. Include 150 feet of 2" conduit with underground reinforced duct bank from tower to WRF in the bid.
5. Include penetration of conduit to office building in the bid.
6. Include 75 feet of 2" conduit within office from building penetration to radio panel.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.
B. Submit calculations to verify that mounting will withstand wind-loading criteria:
   1. Antenna mounting structures shall comply with EIA Standard 222.

1.06 QUALITY ASSURANCE

A. Refer to Section 17050.
B. Procedure for verifying the communications between site shall be as follows:
   1. Perform radio path calculation study to verify the theoretical performance of the proposed paths.
   2. Field verify that the radio paths using field measurement prior to installation.
C. After installation, verify through the use of field collected data, that the installed equipment conforms to reliability benchmark developed as part of the field testing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.
B. Wind:
   1. Provide radio antennas, poles, and towers suitable for wind speeds of 120 miles per hour.
      a. Apply an additional 50% safety factor to the specified wind speed.

1.09 WARRANTY

A. Refer to Section 17050.

1.10 MAINTENANCE

A. Refer to Section 17050.
PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Antenna Structures:
1. Poles:
   a. Manufacturer:
      1) One of the following, or equal:
         a) Hubbell.
         b) Rudd.
   b. Pole shall be 4 inches by 4 inches square aluminum pole with bronze electrocoat finish.
   c. Each pole shall be grounded with dedicated ground rod and grounding conductors.
   d. Provide required accessories for complete installation of antenna.
2. Antenna Towers:
   a. Manufacturer:
      1) One of the following or equal:
         a) Universal Manufacturing Corp, HD 21 Series
   b. Freestanding, rated for an antenna with 5.5 square foot loading at 110 mph.
   c. Provide concrete foundation for antenna base as recommended by tower manufacturer.
   d. Concrete shall be Class A.
   e. Provide with manufacturer’s recommended and supplied base and base mounting kit.
   f. Suitable base for use with a concrete foundation.
   g. Install with base pivot to allow installation and maintenance of antennas at ground level with no need for personnel to climb the tower.
   h. Construction Material: Aluminum.

B. Surge Protector:
1. Provide for antenna installation
2. Cable shields
   a. Andrews, or equal
   b. Install on coaxial radio transmission cable per manufacturer’s recommendation.
      1) Bond cable shield to metal pole or tower.
      2) Provide a dedicated path to ground, as straight as practical, as shown on the Drawings.
3. Coaxial Conductor Protectors:
   a. Polyphaser Model IS series, or approved equal.
   b. Where the radio transceiver is located outside in an RTU enclosure, provide protector in a separate, grounded, metal enclosure located outside of the RTU enclosure Bond protector to the enclosure.
   c. Where the radio transceiver is located indoors, provide protector in a separate enclosure at the building entrance. Enclosure shall have a ¼ inch thick by 1 foot square copper plate that shall be used as a grounding bulkhead.
d. Where distance from the surge protector to the antenna ground rod is less than 20 feet, provide connection from protector enclosure or plate to antenna ground rod using #2/0 copper cable.

e. Where the distance from the surge protector to the radio transceiver exceeds 30 feet, provide a second surge protector within 10 feet of the radio transceiver. Install and ground per Drawings and manufacturer’s recommendation.

PART 3   EXECUTION

3.01 EXAMINATION

A. As specified in Section 17050.

3.02 INSTALLATION

A. Install all equipment per manufacturer’s recommendation.

B. Install lightning and surge protectors outside of enclosure containing radios, RTU’s, or other electronic equipment.

C. Ground all lightning and surge protectors per manufacturer’s recommendations.

D. Seal transmission cable connection to the antenna per manufacturer’s recommendations watertight and sun and wind resistant.

E. Install cable shields near antenna to the coaxial radio transmission cable and bond to the metal pole or dedicated ground path as indicated on the Drawings.

F. Where shown, bond cable to metal pole with a stainless steel bolt and terminal lug.

G. Before mechanically or electroweld bonding sand and brush metal surface to ensure bonding occurs to bare metal.

H. After bonding paint area to match finish as required.

I. Install equipment with ground resistance less than 2 ohms.

END OF SECTION
SECTION 17761

PLC PROGRAMMING SOFTWARE

PART 1  GENERAL

1.01  SUMMARY

A. Section includes requirements for:
   1. Development software to be used with the specified PLC hardware.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.
      c. Section 17720 - Control Systems - Programmable Logic Controllers Hardware.

1.02  REFERENCES

A. Refer to Section 17050.

1.03  DEFINITIONS

A. Refer to Section 17050.

B. Specific Definitions:
   1. Development Operating Software: The software provided by the PLC Manufacturer for use in programming the PLC.
   2. Application software: The software that is programmed specifically for the project.

1.04  SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Product Data:
   1. Programming languages
   2. Operating system requirements

C. Control logic:
   1. Fully annotated copy of programmed PLC logic.
2. Cross-referenced index of all PLC registers or points.

D. Provide Application Software for the specific project process requirements.
   1. Fully annotated copy of programmed PLC logic in its native format.
   2. Cross-referenced index of all PLC registers or points.

1.05 QUALITY ASSURANCE
A. Refer to Section 17050.

1.06 WARRANTY
A. Refer to Section 17050.

1.07 MAINTENANCE
A. Refer to Section 17050.
B. Provide system upgrades and maintenance fixes for a period of 1 year from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. The PLC programming software system shall be manufactured by PLC hardware manufacturer.
B. Provide (no or equal):
   1. Rockwell Software RSLogix 500.

2.02 MANUFACTURED UNITS
A. PLC Programming Software:
   1. Furnish Operating Software capable of monitoring and/or control of the PLCs via the PLC data network:
      a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
      b. Monitor devices at each drop on the PLC data network for proper communications.
      c. Provide the ability to program all PLCs on the PLC data network from the Engineer’s Console.
   2. Operating System:
      a. Microsoft Windows XP.
   3. The PLC programming software shall be suitable for the PLCs furnished under Section 17720.
   4. PLC programming software for all programming, monitoring, searching, and editing:
      a. Usable both on-line, while connected to the PLC, and off-line.
      b. The Operating Software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic, forced elements shall be identifiable by means of color change.

d. Include a search capability to locate any address or element and its program location.

e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.

5. The PLC programming software shall support the following programming languages:
   a. Ladder Diagram.

6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
   a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line by line basis.
   b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
   c. Use a mnemonic associated with each contact, coil, etc., that describes its function.
   d. Utilize the Tag and Loop identification as contained in the P&IDs:
      1) If additional internal coils, timers, etc. are used for a loop they shall contain the loop number.
   e. Provide a cross-reference report of program addresses.

7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
   a. Furnish the operating system software that is the standard uncorrupted product of the PLC Manufacturer with the following minimum functions:
      1) Respond to demands from a program request.
      2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
      3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are assured.
      4) Queuing of requests in order of priority if one or more requested resources are unavailable.
      5) Resolution of contending requests for the same resource in accordance with priority.
      6) Service requests for execution of one program by another.
      7) Transfer data between programs as requested.
      8) Management of all information transfers to and from peripheral devices.
      9) Control and recovery from all program fault conditions.
      10) Diagnose and report real-time hardware device errors.

8. Program Execution:
   a. Application Software - program execution scheduled on a priority basis:
      1) A multilevel priority interrupt structure is required.
      2) Enter into a list of pending programs a program interrupted by a higher priority program:
         a) Resume its execution once it becomes the currently highest priority program.
3) Schedule periodic programs.
4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.

9. Start-up and Restart:
   a. Provide software that initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.
   b. Initialization:
      1) Determination of system status before start-up of initializing operating system software and initializing application software.
      2) Loading of all memory resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.

10. Shutdown:
    a. Where possible provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
    b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
    c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
    d. Alarm PLC failure at the operator interface level.

11. Diagnostics:
    a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. Use the manufacturer's standard diagnostic routines as much as possible.
    c. Furnish diagnostic software and test programs for each significant component in the control system.
    d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.

12. Calendar/Time Program:
    a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.

13. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
       1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
       2) A switch algorithm, which reads the current, value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated, two outputs with one input and one output with 2 inputs.
3) A 3-mode Proportional - Integral - Derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supporting both direct and reverse acting modes.

4) Lead, lag, dead time, and ratio compensators.

5) Integration and totalization of analog process variables.

14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:

   a. In addition, provide spare database points for future expansion.

15. One integrated database can be utilized for all types of analog points or separate databases for each type, in either case, the database for each point must include all specified aspects.

16. All portions of the database must be available for use by the display, report, and other specified software modules.

17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:

   a. Analog Input Signal Types:
      1) Provide software at the RTUs and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.

   b. Input Accuracy:
      1) Inputs must be read with an accuracy of ±0.05 percent full scale or better.
      2) Data conversion errors must be less than 0.05 percent full scale.
      3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once a minute.
      4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.

   c. Blocking:
      1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
      2) For any input so blocked, the operator may manually enter a value to be used as the input value.

   d. Filtering:
      1) For each analog input provide a first order lag digital filter with an adjustable filter factor.

   e. Linearizing:
      1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.

   f. Calculated Values:
      1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc.
      2) These values must be handled the same as real inputs in terms of record keeping, alarming, etc.

   g. Scaling and Zero Suppression:
      1) Provide a conversion program to convert input values into engineering units in a floating-point format.
h. Alarms:
   1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
   2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
   3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
   4) Report return to normal shall also be reported.
   5) Must be possible to inhibit alarms based on external events, ie. lock-out low pump flow alarm when the pump is off.

i. Averages:
   1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
   2) Continuously compute averages, ie. the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
   3) Update hourly averages each minute or at the polling interval for the selected variable.
   4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
   5) Update monthly averages at least once each day and calculate using the results of the daily averages.
   6) At the end of each averaging period, store the average values for the period on the hard disk for historical record keeping and reset the present period average register to the present value of the variable.
   7) The active database must include the present period average and previous period average for each variable and averaging period.

j. Totals:
   1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
   2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
   3) Assign a separate factor for each totalizing interval.
   4) Variables for which totalization is inappropriate must have scaling factors of zero.
   5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record keeping and reset the present period totalization register to zero.
   6) The active database must include the present period total and previous period total for each variable and totalizing period.

k. Engineering Units:
   1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
   2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in GPM, MGD, CFS, and Acre-Feet per day.
   3) Pre-program the conversion of the engineering units, and if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, ie. multiplication of the database attributes by a constant.
   4) The programming method must be at a level and compatible with the specified training of the operator and the OWNER'S personnel.
5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control Modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog Outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

B. General Control Functions:
1. Analog Control Functions:
   a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
   b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR and NXOR functions.
   c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
   d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
2. Discrete Control Functions:
   a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays and time base.
3. Software Support:
   a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
   b. Call each function as required by the configured controls to perform the intended function.
4. Control and Status Discrepancies:
   a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
   b. For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator programmable time delay (time disagree), and then generate a discrepancy (fail) alarm shall be generated.
   c. Involuntary change in the device’s status must also generate an alarm:
      1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
   d. Each command, status, and alarm must cause the color of the symbol to change.
   e. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay.
period selected to be longer than the operating period of the control element:
  1) Delay periods for each final control element must be adjustable at the operator interface.
  2) List all time delays in the final documentation.
5. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package, it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

C. Control Configuration:
  1. Provide software to allow control strategies to be developed and their operation initiated through the operator interface.
  2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, set points and tuning constants, etc.
  3. Provide a mechanism to link separate control functions together into an integrated control strategy.
  4. Provide a mechanism to download operational/control set points developed at any operator interface to any PLC or RTU for operational implementation.
  5. Provide a mechanism to define and implement operational/control set points locally at the PLC or RTU and to upload them to the Operator interface for operational record keeping.
  6. Perform control configurations on-line at the operator interface, the PLC or RTU may be taken off-line when being configured or downloaded.

2.03 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. General:
   1. The control system logic program shall reside at the PLC level.

C. Use the Tag and Loop identifications found on the P&IDs for all tags used and/or assigned as part of the Application Software work provided by the ICSC.

D. Program the PLC logic using Ladder Diagram programming language.

3.02 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Provide a minimum of 4 CD/DVD copies of the following:
   1. Application Software:
      a. Finalized fully annotated copy of programmed PLC logic in its native format.
      b. Cross-referenced index of all PLC registers or points.
3.03 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Training:
   1. Performed by pre-approved and qualified representatives of the ICSC and or manufacturer of the local operator interface software. A representative of the ICSC may perform the training only if the representative has completed the manufacturer’s training course for the PLC programming software.

END OF SECTION
SECTION 17765

HUMAN MACHINE INTERFACE SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Application software to be used in conjunction with the specified Human Machine Interface (HMI) hardware.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Process Control and Instrumentation Systems General Requirements.
      c. Section 17100 - Control Strategies.

C. General requirements:
   1. Software provided under this Contract represent a complete and operating control software system. Achieve the functionality described in this and other sections through a combination of standard control system software and application software developed specifically for this project.
   2. The standard control software listed in this section does not represent a comprehensive list of software necessary to implement the functional requirements of the specifications. Provide all necessary supplemental drivers, utility software, and application software, as required, to meet the functional requirements of the Specifications.
   3. Applications software requirements are described in Section 17100.
   4. License all software for proper operation as described in the Specifications.
   5. License all software provided under this Contract to the OWNER.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.
1.04 SYSTEM DESCRIPTION
A. Provide all HMI hardware and software as indicated in the Contract Documents.

1.05 SUBMITTALS
A. Furnish submittals in accordance with Sections 01330 and 17050.
B. Product Data:
   1. Complete Manufacturer’s brochures that identify HMI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
   2. Manufacturer’s installation instructions.
C. Graphic screens:
   1. Color printouts of each graphic screen and control pop-ups.
D. Operation and Maintenance Manuals:
   1. Complete installation, operation, and testing manuals.
   2. Complete color printouts of each graphic screen and control pop-ups.

1.06 QUALITY ASSURANCE
A. Refer to Section 17050.
B. System Compatibility:
   1. The software must be the standard operating software system designed specifically for use with the Human Machine Interface hardware.
   2. The software must be furnished and developed by the Manufacturer of the HMI hardware.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 17050.

1.08 WARRANTY
A. Refer to Section 17050.

1.09 MAINTENANCE
A. Refer to Section 17050.
B. Provide system upgrades and maintenance fixes for a period of 1 year from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Provide the HMI graphic software system manufactured and recommended by the HMI hardware Manufacturer.
B. One of the following:
   1. C-more Programming Software EA-PGMSW series
   2. No Substitution Permitted.

2.02 MANUFACTURED UNITS

A. Human Machine Interface Software:
   1. Provide a complete software package to be used for programming the
      necessary screens and operator interaction with the HMI’s.
   2. Operating System:
      a. Microsoft Windows XP.
   3. Features and characteristics:
      a. Operates with PC with at least 333 MHz CPU processor, keyboard, super
         VGA adapter, 800 x 600 pixel resolution monitor, 300 MB hard disk space,
         128 MB free RAM, CD-ROM, and USB or Ethernet port.
      b. Include at least 50 types of configurable objects such as switches,
         pushbuttons, gauges, graphs, and custom bitmaps on HMI.
      c. Includes editing tools such as group, order, nudge, rotate, flip, font
         up/down, and undo
      d. Power user object/configuration/editing tool using a property list dialog
         box
      e. Easy creation of control bars that may be used as background screens on
         other related screens
      f. At least 14 different fonts
      g. Allow creation of custom objects
      h. Built-in axis, point, object rotation, multi-state bitmap and object size
         animation of bitmap objects
      i. Trend graph with 16 pens supported
      j. PID faceplate with trend
      k. True historical data logging
      l. Pop-up windows for information and control
      m. Configurable event manager for alarm handling and scheduling
      n. Runtime simulation mode accessible during configuration
      o. Configurable user libraries for project storage and reuse on other projects
   4. Documentation:
      a. Provide complete user documentation, including examples of how to
         operate the various modules within the system.
      b. Provide the documentation in electronic format, HTML based with the
         ability to search for topics by keyword or search or specific text.
   5. On-line Help:
      a. Provide an on-line "help" facility, based upon Windows standard
         Hypertext:
         1) Useful, context-sensitive information on the operation of the package:
            a) That can be invoked on-line through a point-and-click operation.
            b) The "help" facility must also support the ability to perform full
               text word search, add custom comments, bookmark topics, copy
               and pasting into another application, printing, and use of system
               fonts and colors.

2.03 SOURCE QUALITY CONTROL

A. As specified in Section 17050.
PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. All tags used and/or assigned as part of the application programming work are to use the Tag and Loop identifications found on the P&IDs.

C. Station Graphics:
   1. Configure the graphic display for each device in the process area, including but not limited to:
      a. Symbols for:
         1) Pumps.
         2) Valves.
         3) Major instruments.
         4) Flowmeters.
         5) Pressure transmitter.
      b. Alarm symbols including intrusion alarm.
      c. Relevant test and operational data.
      d. Status for each controller or controlled device:
         1) Hand.
         2) Off.
         3) Automatic.
         4) Local.
         5) Remote.
         6) Run.
         7) Call.
         8) Fail.
         9) Open.
        10) Close.
        11) Hold.
        12) Modulate.
      e. Depict a change of state of pumps and valves by a change in color.
   2. Production and Usage Bar Graph:
      a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
   3. System Level Summary:
      a. Show the level for the plant influent and effluent production, etc, via a display using bar graphs and numbers, as determined during the requisite graphics meeting.
   4. Furnish a minimum of 10 screens for Outfall Pump Station and 3 screens Standpipe Station, to be directed by the ENGINEER and OWNER, during construction for each HMI.

3.02 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

END OF SECTION
SECTION 17901

SCHEDULES - FIELD INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

A. The Schedules Field Instrument is not a take-off list. Refer to Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the Instrument Index are defined on the Drawings.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 SCHEDULES FIELD INSTRUMENTS

A. Schedules Field Instruments attached.

END OF SECTION
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<thead>
<tr>
<th>Tag Number</th>
<th>P&amp;ID</th>
<th>Description</th>
<th>Specification Reference</th>
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<th>Units</th>
<th>Set Pt</th>
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<tr>
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<td>SP-N-1</td>
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<td>17201</td>
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Note: Instrumentation supplied as part of motor control centers, variable frequency drives, and motors is not included in this list. Refer to electrical specifications and drawings.

In case of conflict between this list and instrumentation or electrical drawings, the drawings shall prevail.
SECTION 17903

I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Refer to Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 I/O LIST

A. I/O list attached.

END OF SECTION
<table>
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<tr>
<th>Tag Number</th>
<th>Description</th>
<th>Digital Input</th>
<th>Digital Output</th>
<th>Analog Input</th>
<th>Analog Output</th>
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<td>to vfd</td>
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# I/O LIST

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</table>

**Totals**  

|              | 27 | 4  | 10 | 5  |

**Note:**  

1. Input/output designated as "To RTU" in the above list shall be terminated at RTU located at outfall standpipe.
SECTION 17950
TESTING, CALIBRATION, AND COMMISSIONING

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to all process control and instrumentation systems for the entire project.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      c. Section 17050 - Process Control and Instrumentation Systems General Requirements.
      d. Section 17100 - Control Strategies.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Section 01330.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements in Section 17050, Article 1.09.
   2. For each test described in Parts 2 and 3, herein, and described in other sections of Division 17, prepare and submit complete Test Plans, Test Procedures, Test Forms, Test Binders, and Test Reports, and other submittals, as specified below.
   3. Submit Manufacturer’s Certifications and Manufacturer’s Field Reports where required.
   4. Submit Test Plans, Procedures, Forms, and Binders for approval by the ENGINEER before scheduling or performing tests.
5. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
6. Additional Test Form and Test Procedure requirements are specified with individual test requirements.

C. Overall Test Plan:
1. Develop and submit an overall testing plan for the PCIS. The Overall Test Plan to be reviewed and approved by the ENGINEER before detailed test plans, procedures, and forms will be reviewed.
2. Describe the test phases, as they apply specifically to this project and each process system.
3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
4. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
5. Provide examples of proposed forms and checklists.

D. Test Procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), how the testing equipment will be used.
6. Describe the expected role of the ENGINEER, as well as any requirements for assistance from OWNER's staff.
7. Provide the forms and checklists to be used.

E. Test Forms:
1. Provide test and calibration forms and checklists for each of the following:
   a. Calibration.
   c. Loop Validation Tests.
   d. Pre-commissioning Test.
   e. Performance Test.
2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (ENGINEER and OWNER) witnessing the test.
F. Testing Binders:
   1. Sub-system to be tested, provide and submit a Test Binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

G. Factory Acceptance Test Procedure additional minimal requirements:
   1. Prepare and submit a factory acceptance test procedure which includes:
      a. Control system testing block diagram.
      b. Estimated test duration.
      c. Details on the simulator construction, components, and operation.

H. Test Reports:
   1. At the conclusion of each test, submit a complete Test Report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each Test Report is generally required before the start of the sub-system.

1.05 QUALITY ASSURANCE

A. Test Personnel:
   1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this project and the equipment, software, and systems before being assigned to the test program.

1.06 SCHEDULING

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Factory Acceptance Test - General:
   1. Before shipment to the project site, the complete PCIS system including all operator stations, PLCs, communications equipment, and other related equipment, shall be assembled, connected, and all software loaded for a full functional Factory Acceptance Test (FAT) of the integrated system.
   2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
   3. Additional factory tests are specified in other sections of Division 17.
   4. The complete communications system must be factory tested, including actual interfacing with the actual radios used for radio based telemetry systems.
5. The CONTRACTOR’s test personnel shall be responsible for performing tests and recording results.

6. The Factory Acceptance Test (FAT) will be witnessed by the ENGINEER and/or other representatives of the OWNER.

7. Right of Observation: The OWNER retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.

8. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittal.

9. Costs for Repeating Testing: The CONTRACTOR shall pay for ENGINEER’s and other OWNER’s representatives’ travel, subsistence, and labor costs for witnessing the repetition of failed tests.

10. Correction of Deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.

11. Any changes and/or corrections shall be noted on the test forms. ENGINEER shall witness the revisions and/or corrections prior to leaving the test site.

12. If the corrections and/or revisions are too extensive to be made while the ENGINEER is scheduled to be at the FAT test site, the FAT shall be, at the ENGINEER’s sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the CONTRACTOR.

B. Panel Inspections:
1. The ENGINEER will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.

2. Provide panel inspection forms as part of the Factory Acceptance Test procedures submittal.

3. Inspection to include, as a minimum: layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.

C. I/O Test:
1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC, the LOI, and related systems.

2. Test Methodology:
   a. Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).

   b. Discrete outputs: Issue commands from operator interface screen verify output card indicator light and measure response at field wiring terminals.

   c. Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of scale.

   d. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals. Check each point at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of scale.
3. Test forms to include, but not be limited to:
   a. PLC and panel number.
   b. I/O Type.
   c. I/O tag name.
   d. Panel terminal block numbers.
   e. Rack/slot/number of I/O point.
   f. Check-off for correct response for each I/O point.
   g. Space for comments.
   h. Initials of individual performing test.
   i. Date test was performed.
   j. Witness’ signature lines.

D. System Configuration Test:
   1. Demonstrate all general PLC and LOI functions.
   2. Test Forms:
      a. For each test, list the specification page and paragraph of the function
demonstrated, and provide a description of the function.
      b. List the specific tests and steps to be conducted.
      c. For each function, list all of the different sub-functions or ways the function
can be used, and provide a test check-off for each:
         1) Include signature and date lines.

E. Control Logic Test:
   1. The purpose of this test is to verify that all software functions and logic work as
specified, along with any hardwired logic or functions in the tested control
panels.
   2. Testing Requirements:
      a. Demonstrate each function described in Section 17100. Demonstrate in
detail how each function operates under a variety of operating scenarios.
      Test to verify the application of each General Control Strategy function to
each specific Control Strategy or Loop Description.
      b. Demonstrate the proper operation of the programming and configuration
for each Control Strategy or Loop Description. Test each Strategy or Loop
Description on a sentence by sentence and function by function basis.
      Loops with similar or identical logic must each be tested individually.
      c. Demonstrate the proper operation of all digital communication links and
networks. Verify each digital communication I/O point.
      d. Failure Testing: In addition to demonstrating correct operation of all
specified features, special effort shall be made to demonstrate how the
system responds to and recovers from abnormal conditions including, but
not limited to: equipment failure, operator error, communications
subsystem error, communications failures, simulated/forced software
lockups, power failure (both utility power and power to SCADA hardware),
process equipment failure, and high system loading conditions.
   3. Test Forms:
      a. Include the fully revised and approved Control Strategy for the loop being
tested.
      b. Identify the Cause and Effect as each I/O point is toggled through the
simulator. Check boxes shall be provided to track proper and/or improper
operation of the loop.
      c. Any deficiencies or operational changes shall be noted on the forms for
correction and documentation:
1) Include signature and date lines.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. Installation Supervision:
   1. Provide in accordance with Section 17050.

3.02 FIELD QUALITY CONTROL

A. General:
   1. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
   2. Failure Testing:
      a. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
         1) Equipment failure.
         2) Operator error.
         3) Communications sub-system error.
         4) Power failure.
         5) Process equipment failure.
         6) High system loading conditions.
   3. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day. Testing at other times requires approval of the ENGINEER.

B. Manufacturer Services:
   1. Provide in accordance with Section 17050.

C. Sequencing:
   1. See additional requirements in Section 17050, Article 1.09, Sequencing.

D. Calibration:
   1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and system, in conformance with the component Manufacturer's instructions and in accordance with these Specifications.
   2. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
   3. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
   4. Calibration Points:
      a. Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to National Institute of Testing Standards.
   5. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
   6. Analyzer Calibration:
a. Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the Manufacturers' technical representatives.

7. Complete instrument calibration sheets for every field instrument and analyzer.
8. Calibration Tags:
   a. Attach a calibration and testing tag to each instrument, piece of equipment, or system.
   b. Sign the tag when calibration is complete.

E. Loop Check/Validation:
1. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the panel-mounted operator interface.
2. Retest any loop following any necessary corrections.
3. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
4. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
5. Apply provisional settings on controllers and alarm set points.
6. Record all analog loop test data on test forms.
7. Exercise each field device requiring an analog command signal, through the operator interface. Vary, during the validation process, the output from the PLC and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the POI screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
8. Exercise each field device providing a discrete input to the PLC System in the field and observe the proper operation shall be observed at the operator workstation:
   a. Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
   b. Exercise starters, relay contacts, switch contacts, and observe proper operation.
   c. Calibrate and test instruments supplying discrete inputs, and observe proper operation.
9. Test each device accepting a discrete output signal from the PLC. Perform the appropriate operator action at the LOI and confirm the proper operation of the field device:
   a. Stroke valves through outputs from the LOI, and confirm proper directional operation. Confirm travel limits and any feedback signals to the LOI.
   b. Exercise motors starters from the LOI and verify proper operation through direct field observation.
   c. Exercise solenoids and other field devices from the LOI and verify proper operation through direct field observation.
10. Include in the test forms:
   a. Analog input devices:
      1) Calibration range.
2) Calibration data: Input, output, and error at each test value.
3) Analog input associated PLC register address.
4) Value in PLC register at each test point.
5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).

b. Analog output devices:
1) Calibration range.
2) Test value at each test point.
3) Analog output associated PLC register address.
4) Control variable value at field device at each test point.
5) Physical device response at each test point:
   a) Response to be actual valve position, or motor speed, etc.

c. Discrete instrument input devices:
1) Switch setting, contact action, and dead band.
2) Valve position switches:
   a) Response in the PLC as the valve is stroked from the PLC.
   b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
3) Operator interface switches (control stations and other pilot devices) and associated response.
4) Starter and drive auxiliary device contact response.
5) Response of all other discrete inputs to the PLC.

d. Discrete output devices:
1) Observed response of field device to the discrete output from the PLC.
2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

e. Test equipment used and associated serial numbers.

F. Pre-commissioning (Functional) Test:
1. General:
   a. Commence pre-commissioning tests after completion of all loop check/validation tests:
      1) Reference Section 17050, Article 1.09, Sequencing and Scheduling.
   b. Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
   c. Pre-commissioning testing to generally occur in conjunction with Functional Testing specified in Section 01756.
   d. Additional tests are specified in other Division 17 sections.
   e. Follow approved detailed test procedures and check lists for all pre-commissioning and test activities.

2. Control Logic Operational Validation:
   a. The purpose of Control Logic Validation is to field test the operation of the complete control system, including all parts of the PLC and LOI System, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
   b. Demonstrate all control functionality shown on the P&IDs, Control Schematics, and other Drawings, and specified in the Loop Descriptions, Control Strategies, Electrical Specifications, and Mechanical Equipment Specifications.
c. Test in detail on a function-by-function and sentence-by-sentence basis.
d. Thoroughly test all hardware and software functions:
   1) Including all hardwired and software control circuit interlocks and alarms.
e. Test final control elements, controlled equipment, control panels, and ancillary equipment under start-up, shut down, and steady-state operating conditions to verify all logic and control is achieved.
f. Control Logic Validation tests to include, but not limited to: a repeat of all Control Logic Tests from the Factory Acceptance Tests, modified and expanded to include all field instruments, control panels, circuits, and equipment.

3. Loop Tuning:
   a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
   b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
   c. If excessive oscillations or system instability occur, as determined by the ENGINEER, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.

4. Pre-commissioning Validation Sheets:
   a. Document each pre-commissioning test on an approved test form.
   b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the ENGINEER. Show tuning parameters on the charts, along with time, date, and sign-off by CONTRACTOR and ENGINEER.
   c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
      1) Loop number and P&ID number.
      2) Control Strategy, or reference to specification tested.
      3) Test Procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence Loop Test Checklist forms modified to meet the requirements of the Pre-commissioning test. Otherwise, create new forms.
   d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall Plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function and/or text from specification.
      3) Test procedures: use the FAT Loop Test Checklist forms modified to meet the specific testing conditions of the Pre-commissioning Test.
5. Pre-commissioning Certification:
   a. Document via a certified report the completion of all pre-commissioning and test activities:
      1) Including all test forms with test data entered, submitted to the ENGINEER with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.

3.03 DEMONSTRATION AND TRAINING

A. Performance/Reliability/Operational Tests:
   1. After successful completion of the pre-commissioning test as accepted by the ENGINEER and OWNER, the performance test can proceed.
   2. Complete training and instruction of the OWNER's personnel in conformance with paragraph 1.09 Sequencing and Scheduling of Section 17050.

B. The Performance Test may be performed concurrently with the 7-Day Operational Test noted in Section 01756.

C. General:
   1. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire project.
   2. The complete PLC control and SCADA system must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:
      a. Include time of occurrence and duration of each failure.
   3. Provide a competently trained technician or programmer on call for the project site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the project site:
      a. 24 hours or less, for a major failure.
   4. The Performance Test duration:
      a. 7 days.
   5. Test and use; the entire process control system under standard operating conditions.

D. PLC and LOI System Testing:
   1. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
   2. Failure of the System during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
      a. Corrective action is required before restarting the acceptance test.

E. Failures:
   1. Classify failures as either major or minor.
      a. Minor Failure:
         1) A small and non-critical component failure or software problem that can be corrected by the OWNER's operators.
         2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
4) Failure of one printer, or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e. alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.

b. Major Failure:
1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
2) Cause termination of the performance test.
3) Start a new acceptance test when the causes of a major failure have been corrected.
4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

F. Technician Report:
1. Each time a technician is required to respond to a system malfunction, he or she must complete a report which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
2. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
4. Each report shall be submitted within 24 hours to the ENGINEER and the OWNER, or its representative.

3.04 SCHEDULES

A. Example Test Forms:
1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this project.
2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.
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<th>INSTRUMENT LOOP NO.</th>
<th>SERVICE DESCRIPTION</th>
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A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- [ ] INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- [ ] INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- [ ] INSTRUMENT LOOP WIRING DIAGRAMS
- [ ] INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- [ ] SIZING CALCULATIONS
- [ ] INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- [ ] NAMEPLATE SCHEDULE (APPLICABLE PART)
- [ ] VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?  
No  Yes

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### SWITCHES

#### INSTALLATION AND CALIBRATION CHECKLIST

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- [ ] CORRESPONDS TO SPECIFICATION SHEET NO.
- [ ] WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- [ ] INSTALLATION CORRECT PER DETAIL NO.
- [ ] ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- [ ] INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- [ ] ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

**INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?**

- [ ] No
- [ ] Yes

### FIELD CALIBRATION CHECK

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**NOTE:** PERM IS ABBREVIATED FOR PERMISSIVE
### TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?  
- No  
- Yes

INSTRUMENT TYPE INDICATOR
- TRANSMITTER
- CONTROLLER
- OTHER DESCRIPTION

INSTRUMENT TAG NO.  SERIAL NO.  

SERVICE DESCRIPTION

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- WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- INSTALLATION CORRECT PER DETAIL NO.
- ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

### FIELD CALIBRATION CHECK

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TRANSMITTER/CONTROLLER/INDICATOR
INSTALLATION AND CALIBRATION
CHECKLIST

☐ DIRECT  ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN
☐ ACTION VERIFIED AT ________ SPAN

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PRE-TUNE SETTINGS

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REMARKS

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CHECKED BY (COMPANY) ___________________________  ACCEPTED BY (COMPANY) ______________________

SIGNATURE ___________________________  SIGNATURE ___________________________

DATE ___________________________  DATE ___________________________
INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? NO YES

TYPE OF INSTRUMENT

INSTRUMENT TAG NO. ________________________ SERIAL NO. ________________________

SERVICE DESCRIPTION

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER SPEC SHEET
☐ VERIFIED PER P&ID NO. ________________________
☐ CORRESPONDS TO SPECIFICATION SHEET NO. ________________________
☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ________________________
☐ INSTALLATION CORRECT PER DETAIL NO. ________________________
☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS

CHECKED BY (COMPANY) ________________________ ACCEPTED BY (COMPANY) ________________________

SIGNATURE ________________________ SIGNATURE ________________________

DATE ________________________ DATE ________________________
## TRANSDUCER CHECK

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CHECK BELOW, IF TRUE:

- [ ] BENCH CALIBRATED PER ABOVE
- [ ] VERIFIED PER P&ID NO. __________________________________________________________
- [ ] CORRESPONDS TO SPECIFICATION SHEET NO.
  - [ ] VALVE SPECIFICATION NO. _______________________________________________________
  - [ ] TRANSDUCER SPECIFICATION NO. ________________________________________________
  - [ ] SOLENOID SPECIFICATION NO. ________________________________________________
- [ ] WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ________________________________
- [ ] INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS
  - [ ] VALVE DETAIL NO. _____________________________________________________________
  - [ ] TRANSDUCER DETAIL NO. _____________________________________________________
  - [ ] SOLENOID DETAIL NO. _______________________________________________________

END OF SECTION