CONTRACT DOCUMENTS FOR

CONSTRUCTION OF THE

BIOSOLIDS DEWATERING SYSTEM IMPROVEMENTS
AT THE
WESTSIDE REGIONAL WATER RECLAMATION FACILITY

ISSUED FOR BID

FEBRUARY 2020

SPECIFICATIONS VOLUME 2
(DIVISIONS 14-17)

CA 8571

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DESIGN OF BIOSOLIDS DEWATERING SYSTEM IMPROVEMENTS
AT THE
WESTSIDE REGIONAL SLUDGE DEWATERING FACILITY IMPROVEMENTS

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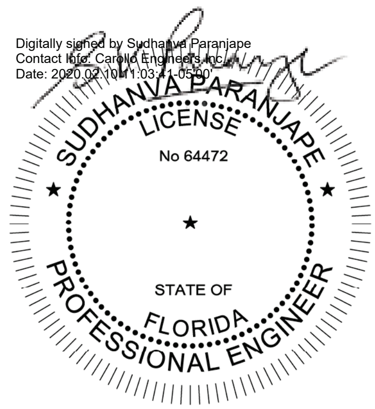

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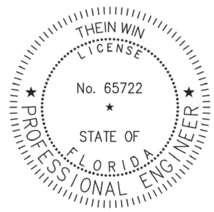

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CITY OF DAYTONA BEACH

BIOSOLIDS DEWATERING SYSTEM IMPROVEMENTS AT THE WESTSIDE REGIONAL WATER RECLAMATION FACILITY

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SECTION 14555

SHAFTLESS SCREW CONVEYORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Shaftless screw conveyors.

B. The Manufacturer shall be responsible for the supply of the shaftless screw conveyor system as described herein.

C. Equipment Tag Numbers:
   1. H-CON-01 - Horizontal Conveyor No. 1.
   2. I-CON-01 - Inclined Conveyor No. 1.
   3. L-CON-01 - Loading Conveyor No. 1.
   4. H-CON-02 - Horizontal Conveyor No. 2 (future).
   5. I-CON-02 - Inclined Conveyor No. 2 (future).
   6. CK-E-SE-00X (X=1 thru 6) - six motorized gates for truck loading conveyor.
   7. LCP-CCP - Conveyor Control Panel.
   8. LCP-TLCP - Truck Loading Conveyor Control Panel.
   9. LCP-TLRCP - Truck Loading Remote Control Panel.

1.02 REFERENCES

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

B. American Institute of Steel Construction (AISC).

C. American Iron and Steel Institute (AISI).

D. American Welding Society (AWS).

E. Conveyor Equipment Manufacturers Association (CEMA):
   1. 350-Screw Conveyors.

F. National Electrical Code (NEC).

G. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA: Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. General:
   1. Two (2) shaftless screw conveyors - one horizontal and one inclined per Belt Filter Press, and one reversible unloading conveyor with eight (8) drops, of which six (6) will have powered gates to collect and transport a continuous load of dewatered municipal waste activated sludge from belt filter presses (BFPs) to one of two tractor trailer loading zones. The unloading conveyor shall be designed to accept and handle cake from the future inclined conveyor.
   2. The shaftless screw conveyor system equipment shall include, but not be limited to, the following items, all of which shall be supplied by the shaftless screw conveyor manufacturer:
      a. Spiral fighting.
      b. End shaft.
      c. Drive.
      d. Troughs and liners.
      e. Covers.
      f. Chutes and hoppers.
      g. Conveyor supports.
      h. Zero speed switches.
      i. Safety accessories.
   3. The conveyors shall be suitable for both intermittent and continuous loading and operation.
   4. Controls and control strategy: As specified in Section 17000 - Instrumentation and Controls and as indicated on the Drawings.

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

Conveyor	H-CON-01	I-CON-01	L-CON-01
Design capacity - cu ft/hr	290 /each	290 /each	435 /each
Conveyed material density - lbs/cu ft	50	50	50
Conveyed material solids concentration (min) - %	14	14	14
Conveyed material solids concentration (max) - %	20	20	20
Length - feet	See Drawings (Note 1)	See Drawings (Note 1)	See Drawings (Note 1)
Incline angle	Horizontal	20°	Horizontal
Screw speed (max) - rpm	≤ 20	≤ 20	≤ 20
Maximum filling factor at design capacity (based on 100% being the circular area calculated from the screw outside diameter, not trough cross-sectional area) - %	≤ 45	≤ 45	≤ 45
Loss of volumetric capacity due to incline - %	0	50	0
Flight outside screw diameter (min) - inches	≥ 11.25	≥ 11.25	≥ 13.25
Inner spiral required	By Mfgr	By Mfgr	By Mfgr
Trough width (min) - inches	≥ 12	≥ 12	≥ 14
Trough height (max) - inches	≤ 21	≤ 21	≤ 21
Trough thickness (min) - inches	11 gauge	11 gauge	10 gauge
Trough liner thickness (min) - inches	3/8	3/8	1/2
Cover thickness (min)	11 gauge	11 gauge	10 gauge
Drive end plate thickness (min) - inches	3/8	3/8	3/8
Non-drive end plate thickness (min) - inches	3/8	3/8	3/8
Location of drive (Note 3)	Per manufacturer	Per manufacturer	Per manufacturer
Minimum Drive horsepower	7.5	5.0	10.0
Reversing screw	No	No	Yes

Notes:

(1) The drawings are based on available record drawings. The dimensions shown on the drawings should be field verified. The exact dimensions shall be verified by the installing Contractor and Conveyor Manufacturer's representative(s) and shall be finalized during shop drawing preparation.
(2) Provide constant torque or current limiting soft starts as indicated on the electrical drawings.
(3) For the inclined conveyor if the drive is located at the truck loading station, Contractor shall verify dimensions to ensure the drive can be located and supported off the existing truck loading station.

3. The spiral flights shall be designed with the stability to prevent distortion and jumping in the trough. Hold-down provisions shall be provided described below.

4. The "spring effect" (maximum compression or elongation) of the spiral shall not exceed 0.10 inch per 1 foot of length at design load conditions when the following equation is used:

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

   where:
   k = (4c-1)/(4c-4) + 0.615/c
   c = 2r/b
   r = spiral radius
   n = number of pitches
   b = spiral width
   h = spiral thickness
   P = Load
   G = 11,000,000 psi
   (Mark's Handbook for Mechanical Engineers, latest edition)

5. In the extreme condition of start-up with 50 percent trough filling, at 250 percent of the motor nameplate horsepower, the maximum torque produced by the drive unit shall be not more than 75 percent of the torsional rating of the outermost fibers of the spiral flight.
6. The torque capacity of the drive unit shall be sufficient to start the conveyor with 100 percent trough loading.

C. Supports:
   1. Provide full structural steel supports:
      a. The inclined and horizontal conveyors shall be supported from the concrete floor as shown in the drawings.
      b. The loading conveyor shall be suspended from concrete structural members over the truck loading area as shown in the drawings.
   2. Provide conveyor supports fabricated of Type 316L stainless steel structural members:
      a. The conveyor manufacturer shall be responsible for sizing the support structural members and anchors and shall include all required bracing to meet the application and Specification requirements.
      b. For support design, assume the transport conveyor troughs 100 percent full with material weighing 60 pound per cubic feet.
   3. All structural supporting members shall be designed such that the ratio of the unbraced length to least radius of gyration (slenderness ratio) shall not exceed 120 for any compression member and shall not exceed 240 for any tension member (of angles about Z-Z axis).
   4. Design the supports of avoid interference with other equipment or equipment supports.
   5. Conveyor support spacing shall not exceed 12 feet:
      a. The conveyor manufacturer shall allow for 1-inch of grout beneath each support footpad for the installing contractor to compensate for uneven floor elevation.
   6. Supports shall be shop fabricated, assembled, fitted to the conveyor, and match marked with the associated conveyor segments prior to shipment to the job site.
   7. All shop welding shall conform to the latest standards of the AWS.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment.

B. Installation List:
   1. To verify conformance with the specified Manufacturer Qualifications as specified in Article 1.06.
   2. Must be included with the Substitution Request Form as part of the Proposed Substitutes “Or Equal” Submittal, and the regular Shop Drawing Submittal in accordance with Section 01330.
   3. Include the following information as a minimum:
      a. Name and location of installation.
      b. Name and telephone number of person in direct responsible charge of the equipment.
      c. Month and year the equipment was placed in operation.
      d. Size of Equipment: Length and diameter of shaftless screw.
      e. Design capacity and corresponding filling factor.
      f. Indicate whether single or double (outer plus inner) spiral was used.
      g. Manufacturer of spiral.
      h. Conveyor incline angle.
      i. Location of Drive: Push or pull system.
      j. Drive horsepower.
      k. Number of units installed.
      l. Service and material conveyed.
      m. Liner material.
      n. Panel layout, bill of materials, wiring diagrams, component cut sheets, etc.

C. Product data.

D. Shop drawings: Include manufacturer's complete erection, installation, and adjustment instructions and recommendations, details of parts individually and severally, and detailed test procedures for field-testing. Also include screw diameter, pitch, rotational speed and torque tube diameter, equipment performance specifications, drive details, including service factor of gear reducer based on absorbed horsepower and installed motor horsepower. All drawings to be generated using a 3D Computer Aided Drafting program including but not limited to Autodesk Inventor, PTC ProEngineer, Dassault Systèmes SOLIDWORKS, or equal.

E. Calculations: prepared, signed, and sealed by Professional Engineer registered in the State of Florida. Submit certified capacity, power and elongation calculations for the screw conveyor and spiral, respectively. Submit bearing life calculations for the gear reducer bearings and/or drive end bearings.

F. Operation and Maintenance Manuals.

G. Submit structural design calculations and all other product drawings and information required for a complete submittal:
   1. The structural calculations for the supports and anchoring of the unit and associated accessories as well any other structural supports as part of the system shall be done, signed, and stamped by a structural professional engineer in the state where the Project is located.

2. To insure Structural calculations are accurate for approved dimensions, Submittal may be submitted for dimensional approval prior to structural calculations and PE Stamp.

H. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

I. Video of factory test run on DVD or uploaded to FTP or Dropbox site.

J. Submit warranty indicating liner and/or screw shall be replaced, along with labor to install said equipment, if either component fails within 15,000 hours or 3 years of equipment start-up, whichever occurs first.

1.06 QUALITY ASSURANCE

A. Conveyor Manufacturer Qualifications:
   1. Minimum 10 years' experience in construction and manufacturing of shaftless screw conveyor systems substantially similar to the specified equipment for the municipal wastewater treatment industry. The installation or reselling of shaftless screw conveyors shall not qualify as construction or manufacturing experience and will not be considered towards meeting the experience requirements.
   2. Installation List: Submit evidence of satisfactory operation of equipment similar to the specified equipment in at least 20 separate facilities in North America in accordance with the following requirements:
      a. All equipment on the submitted installation list shall:
         1) Be in municipal wastewater industry application.
         2) Have the same spiral manufacturer and screw conveyor system manufacturer as proposed for this project.
         3) Have a minimum spiral diameter of 10 inches.
         4) Have a minimum spiral length of 30 feet.
         5) Be a conveyor separate from a compactor unit.
      b. At least 3 of the installations shall also satisfy the following requirements:
         1) Years in Service: Minimum 3 years.
         2) Service: Dewatered municipal waste activated sludge.
         3) Incline: Between 20 degrees and 60 degrees.
         4) Spiral Length: Minimum 40 feet.
         5) Spiral Diameter: Minimum 10 inches.
      c. Multiple equipment units at a plant shall be considered as one installation toward meeting the experience requirements.
   3. Manufacturer shall carry a current, valid certificate of ISO-Certification.
   4. Manufacturer shall be a current member of the Conveyor Equipment Manufacturer's Association.
   5. Manufacturer must carry an engineering staff of at least 10 degreed mechanical engineers.

6. Manufacturer must fabricate at least 75 percent of the conveyor parts by weight and fully assemble and test the conveyors at the same facility where the engineering design staff is located. Manufacturers who subcontract the fabrication or assembly or procure the 75 percent parts from offsite are unacceptable to meet the desired standards for quality and design.

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

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

D. Manufacturer's shop welds, welding procedures, and welders: Qualified and certified in accordance with the requirements of ANSI/AWS D1.1, or ASME Boiler and Pressure Vessel Code Section IX. Welding shall be by the metal-arc method or gas-shield arc method described in the American Welding Society's Welding Handbook as supplemented by other AWS standards. Qualifications of welders shall comply with AWS Standard AWS D1.198. The equipment must be inspected by AWS certified welding inspectors and instructors.

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

F. Manufacturer's not listed in this specification shall provide a formal request to the Owner 25 days before the opening of the bids and provide all of the above information (Section 1.06 A through D) to the Owner for approval along with the formal request. Additionally Manufacturer shall also clearly state all exceptions taken to this specification in the submittal. Owner reserves the right to accept or reject the bids for no reason. Owner may require manufacturer to submit additional information to be considered as "approved equal".

1.07 DELIVERY, STORAGE AND HANDLING

A. MANUFACTURER shall coordinate delivery, shipping and handling, field dimensions and coordination with the installing Contractor and Owner. The MANUFACTURER shall deliver all conveyors at agreed upon dates with the installing Contractor and Owner. MANUFACTURER shall request the construction schedule from the Installing Contractor after the Contractor receives the Notice-to-Proceed (NTP) from the OWNER for the construction of dewatering system improvements. MANUFACTURER shall request the equipment delivery schedule confirmation at a minimum 60 days in advance and another at a minimum 15 days in advance of shipping the unit(s). MANUFACTURER shall provide the installing Contractor all necessary information to proper handling of the delivery and storage of the equipment and any assembly required on-site as necessary before installation.

B. Shaftless Screw Conveyor System:
   1. Factory assembled before shipment to ensure proper fit of all components.
   2. Ship equipment in the minimum practical number of pieces for field assembly by the Contractor.
   3. Refer to Section 01600 for additional requirements.

1.08 WARRANTY

A. MANUFACTURER shall warrant conveyor equipment (delivered under this solicitation) free of defects in material and workmanship for a period of 3 years from the date of Operational Acceptance or date of first beneficial use of the equipment by the Owner (or 42 months from shipment, whichever comes first). Cover parts and labor except for normal wear of the trough liner. The shaftless spiral must carry a warranty of 5 years beneficial use guarantee before replacement is needed.

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

1.09 MAINTENANCE

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

Item	Quantity
1. Trough Liners	1 set for the longest conveyor of each size
2. Motor for Drive Unit	1 each size
3. Shaft Seals	1 set of all shaft seals for each shaft size
4. Rotation Sensor	1 set of rotation sensor
5. Emergency Stop Switch	1 set without enclosure

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Shaftless screw conveyor: One of the following or approved equal:
1. Spirac.
2. Keystone.
3. KWS Manufacturing Company.
4. Custom Conveyor Corporation.

B. For manufacturers to be considered as “Approved Equal”, submit all documentation to the Owner as per Specification 01600, Section 1.05.E.

2.02 MATERIALS

A. Shaftless screw conveyor: The shaftless screw conveyor shall be new and of current manufacture, and shall be designed to transfer municipal dewatered sludge as specified and shall be constructed in accordance with CEMA 350 standards.

B. Trough: AISI Type 316 stainless steel.

C. Drive and End Plates: AISI Type 316 stainless steel.

D. Covers: AISI Type 316 stainless steel.

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

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

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

H. Supports: AISI Type 316L stainless steel.

I. Hardware, Fasteners, Lifting Lugs: Type 18-8 stainless steel.

J. Drive Shaft: AISI 1045. Shafts to be complete with flanged ends and mating bolt holes to match the conveyor spiral flanged end plates. Shaft to be integral with the shaft flange as a single-piece. Shafts welded to a flange are not acceptable.

K. Conveyor support system structural elements, including but not limited to anchor bolts, support framing, and structural connection bolts: As specified in Section 05120 - Structural Steel.

L. Conveyor system welded elements: Materials as specified in Section 05120 - Structural Steel.

M. Fabrication:
   1. All welds shall be continuous unless otherwise specified.
   2. Facing surfaces of bolted joints shall be shop primed.
   3. Passivate or bead blast stainless steel welds.
   4. Facing surfaces of field welded components shall be beveled and match marked.

N. Edge grinding: Sharp corners of all cut and sheared edges shall be made smooth.

2.03 SPIRAL FLIGHTING

A. Design spiral flighting to convey material without a center shaft and designed with the stability to prevent distortion and jumping in the trough.

B. Form spiral flighting in sections from 1 continuous flat hot-rolled spring steel bar:
   1. Material shall be corrosion-resistant micro-alloy steel bar and be concentric to within 1/16 inch.
   2. Spirals formed from cut plate are not permitted.

C. The spiral shall be cold formed into the final diameter and pitched in 2 separate forming stages to reduce spiral neck-down and eliminate spiral cracking.

D. The spiral shall be rolled in such a way as to limit "neck-down" of the outside edge of the cold-rolled spiral to 10 percent of the thickness of the inside edge of the spiral:
   1. The spiral edges shall be smooth in the as-rolled condition and not show cracks or grinding marks when tested with a dye penetrant.

E. Connect spiral flighting to the drive shaft by welding the spirals to a 3/4-inch minimum circular torque plate properly reinforced with a gusset 180 degrees of the coupling disk:
   1. A separate connection plate shall be bored with a hole equal to the shaft, and the drive shaft shall be concentrically welded to the plate to effectively transmit torque and bolted to the torque plate.
   2. All welded connections on the spiral including drive plate, gusset and spiral splices should be mag flux tested to ensure there are no defects in the welds.

F. Spiral connections shall be AWS requalified full penetration welds:
   1. Flights shall be welded in a jig to assure true alignment.

G. All spirals shall have a welded insert to increase strength and decrease fall back.

H. Spirals shall be manufactured by the conveyor manufacturer, since the spiral is integral with successful operation of the unit, spirals purchased from third party vendors will not be allowed.

2.04 TROUGH AND COVER

A. Trough shall meet the dimensional standards of CEMA 350. Trough size, thickness, and material shall be as specified herein.

B. Trough shall be U-shaped with stiffeners across the top, fastened to both sides of the trough to maintain trough shape and act as a face seal for each cover section. At filling openings, provide a trough stiffener on each side of opening.

C. Apply a full-face continuous neoprene gasket to the entire top face of the trough top flange and stiffeners.

D. Trough sections shall be joined using bolted flanged connections and neoprene gaskets.

E. Equip each trough with filling and/or discharge openings as indicated in the Drawings. Each filling and discharge opening shall be flanged, suitable for connection to other devices such as slide gates, chutes, and hoppers:
   1. Discharge openings from conveyors shall have a length not less than 1.5 times the spiral pitch nor less than the dimension indicated on the Drawings.
   2. Discharge openings from conveyors shall have a width equal to the full width of the U-trough.

F. Flare the trough immediately above top of liner at the locations of filling chutes where indicated on the Drawings.

G. Provide each transport conveyor with two 3-inch flanged drain outlet located at each end plate as shown on the Drawings.

H. The portion of each trough that is not covered by a filling chute shall be covered by a bolted cover of a material identical to the trough.

I. Cover sections shall be 5-foot length, maximum.

J. Holddown provisions - Holddown provisions shall be provided as recommended by the manufacturer to secure spiral flighting in trough bottom. Holddowns shall be bolted to trough and design shall not impede material flow. As a minimum, holddown shall be provided every 10 pitches of spiral length and each holddown shall span 1.5 pitches as a minimum. Holddown provisions shall not require regular maintenance and any wear component shall have a life greater than or equal to the life of the trough liner.

K. Covers shall be bolted at 24-inch spacing maximum. To prevent unsafe access to the conveyors, quick opening covers will not be accepted.

L. Provide covers with stainless steel hinged observation hatches at suitable locations. At each hatch location, provide the cover with a stainless steel mesh guard to block access to the spiral.

M. Provide each conveyor with two 6-inch flanged connections to connect to odor control ductwork as indicated on the drawings. Only one connection may be used. The other connection shall then be closed with a blind flange.

2.05 TROUGH LINER

A. Provide the conveyor trough with a wear liner fabricated of ultra high molecular weight polyethylene (UHMWPE) impregnated with a lubricating agent.

B. Wear liner thickness shall be as specified herein.

C. The liner shall be provided with a visual indication (using colors) of excess wear.

D. Wear liner coefficient of thermal expansion shall match that of the trough material.

E. Wear liner shall be the following type, or approved equal:
1. Wear-Alert UHMW by KWS Mfg.
2. DURAFLO SPX by SPIRAC, Inc.
3. POLYSTONE M by Custom Conveyor Corporation.

F. The wear liner shall be furnished in maximum 4-foot long sections. Shorter liner sections will be required at some locations to provide liner joints at specific locations indicated on the Drawings.

G. Each liner section shall be held in place with a minimum of four Type 316L retainer bars permanently welded to the trough at 180 degrees along the trough. Fasteners that penetrate the trough will not be accepted.

2.06 SUPPORTS

A. Provide conveyor supports fabricated of Type 316L stainless steel structural members. The support types and configurations shall be as shown on the Drawings. The conveyor manufacturer shall be responsible for sizing the support structural members and anchors and shall include all required bracing to meet the application and Specifications requirements. For support design, assume the conveyor trough is 100 percent full with material weighing 60 lb/cf.

B. All structural supporting members shall be designed such that the ratio of the unbraced length to least radius of gyration (slenderness ratio) shall not exceed 120 for any compression member and shall not exceed 240 for any tension member (of angles about Z axis).

C. All structural members and connections shall be designed so that the unit stresses will not exceed the American Institute of Steel Construction (AISC) allowable stresses by more than 1/3 when subject to loading of twice the maximum design operating torque of the spiral conveyor drive motors.

D. At a minimum, each conveyor shall be provided with supports at each end, with intermediate supports as shown on the Drawings. If required, provide additional supports as determined by the calculations.

E. Design the supports to avoid interference with other equipment or equipment supports.

F. Conveyor support spacing shall not exceed 12 feet.

G. Supports shall be shop fabricated, assembled, fitted to the conveyor, and match marked with the associated conveyor segments prior to shipment to the job site.

H. All shop welding shall conform to the latest standards of the American Welding Society (AWS).

I. Adjustable packing gland seal shall be provided where the drive shaft projects through conveyor end plate. Seals shall utilize a split follower to facilitate the changing of the packing material and to be complete with not less than three (3) 1/2 inch square packing rings per stuffing box. Provide grease fitting with lantern ring to lubricate the packing rings.

2.07 CHUTES AND HOPPERS

A. The chutes and hoppers shall be sized to accommodate the entire discharge end from the specified belt filter press per Section 11362. Conveyor manufacturer shall coordinate with BFP Manufacturer for system responsibility for sizing. Any chutes and hopper of inadequate dimensions shall be changed out at no cost to the Owner.

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

C. Construct of 3/16-inch wall thickness with 3/8-inch flanges for connection to the cake pump(s) one end. Provide chutes with external body reinforcing stiffeners as required.

D. Provide neoprene gaskets at flanged connections.

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

F. Provide each chute section with handles and lifting lugs for easy handling for sections weighing over 100 lbs.

G. Provide chutes with flexible neoprene sections where applicable. Attach neoprene chute section to stainless steel chute using stainless steel clamps.

H. Provide chutes with supports as required. Include chute support calculations with submittal for review by the Engineer.

2.08 DRIVE UNITS

A. Each spiral conveyor shall be driven by a constant-speed integral gear reducer/motor drive unit mounted to an adapter flange, which is in turn mounted to the end plate of the conveyor.

B. The adapter flange shall allow the leakage of any material from the conveyor trough to atmosphere rather than into the gear reducer/motor drive unit. Direct coupling of the gear reducer/motor drive unit to the end flange of the conveyor will not be accepted.

C. The drive unit shall be rigidly supported so there is no visible “wobble” movement under any operating condition.

D. The drive system shall be designed, at a minimum, to start the conveyor from a dead stop with the trough filled throughout its entire cross sectional area and length with partially dried and hardened dewatered material.

E. The drive unit shall be a hollow shaft mounted drive.

F. Gear Reducers:
1. All gears shall be AGMA Class II, single, double, or triple reduction, helical gear units with high capacity roller bearings.
2. Bearings shall be designed for the thrust loads from the fully loaded startup condition and shall have an AFBMA B10 life of 30,000 hours minimum.
3. V-belt driven speed reducers or chain driven reducers will not be accepted.
4. The reducer shall be the standard air-cooled unit with no auxiliary cooling required.
5. The gear reducer shall be sized with a torque service factor of 1.5 times the absorbed power or 1.1 times the motor nameplate, at the driven shaft speed, whichever is greater.

G. Motor:
1. Motor shall be as specified in Division 16 except as modified herein.
2. Motor horsepower for each conveyor shall be as specified herein.
3. Constant speed, 460 V, 60 Hz, 3 phase.
4. Maximum speed: 1750 rpm.
5. Ambient temperature (degrees C): 40.

6. Service factor: 1.15.
7. Insulation: Class F.
8. Temperature rise under full load: Not to exceed that for Class B insulation.
9. Enclosure: TEFC.
10. Design B speed/torque characteristics.

H. Drive unit shall be manufactured by Nord, SEW Eurodrive; or approved equal.

2.09 CONTROLS AND ACCESSORIES (FURNISHED BY THE CONVEYOR MANUFACTURER)

A. A NEMA 4X 316 SST conveyor control panel shall be furnished to accommodate both the horizontal and inclined conveyors to be installed in this contract and the additional horizontal and inclined conveyors which are planned for future installation as shown in the Drawings. Only one horizontal and one inclined conveyor will be installed but the control panel shall be provided with all wiring, starters, etc. for two horizontal and two inclined conveyor systems. The conveyor control panel (LCP-CCP) shall house NEMA non-reversing starters associated with two horizontal and two inclined conveyors and control associated with those conveyors. The power supply for the LCP-CCP shall be 480V, 3-phase, 60-Hz. The LCP-CCP shall be provide with main breaker with external handle. Furnish and install SPD for incoming 480V power in the LCP-CCP. Provide each starter of conveyor to have “Hand-Off-Remote” selector switch for manual and automatic control, “running”, “failed” LED indication lights, reset push button, etc. and shall be mounted on the dead front of the control panel. Provide step-down transformer and other power supplies as required for control power of the LCP-CCP. Furnish and install all necessary terminal blocks, wireways, breakers, fuses, relays, timers, etc. as needed for a complete and functional conveyor control system in place. See Divisions 16 and 17 for additional information on controls. Refer to Instrumentation drawings for additional requirements and provide accordingly.

B. A NEMA 4X 316 SST truck loading conveyor control panel shall be furnished for truck loading conveyor and six truck loading motorized gates. The truck loading conveyor control panel (LCP-TLCCP) shall house NEMA reversing starter associated with truck loading conveyor. The power supply for the LCP-TLCCP shall be 480V, 3-phase, 60-Hz. The LCP-TLCCP shall be provide with main breaker with external handle. Furnish and install SPD for incoming 480V power in the LCP-TLCCP. Provide starter of truck loading conveyor to have “Local-Off-Remote” and “Left-Right” selector switches for manual and automatic control, “running left”, “running right”, “failed” LED indication lights, reset push button, etc. and shall be mounted on the dead front of the control panel. Provide step-down transformer and other power supplies as required for control power of the TLCCP. LCP-TLCCP shall also have “Local-Remote” and “Open-Close” selector switches for each motorized gate and “Gate Open” and “Gate Closed” LED indication light for each motorized gate. Furnish and install all necessary terminal blocks, wireways, breakers, fuses, relays, timers, etc. as needed for a complete and functional tuck loading conveyor and gate control system in place. See Divisions 16 and 17 for additional information on controls. Refer to Instrumentation drawings for additional requirements and provide accordingly.

C. A NEMA 4X 316 SST truck loading remote control panel (LCP-TLRCP) shall be furnished by the Conveyor MANUFACTURER and Installing Contractor shall install remote control panel near the truck loading station. LCP-TLRCP shall have a minimum of “OFF-ON” selector switch for truck loading conveyor, “Running”, and “Failed” LED indication light.

D. Emergency stop cables:
   1. Provide emergency stop cables on both sides of the conveyor with 2 switches per 50 feet minimum length of cable.
   2. Cable shall be orange plastic coated safety cable mounted through eyebolt spaced no more than 10 feet.

E. Non-contacting-type zero-motion switches shall be provided and installed so they stop the operation of the drive motor when conveyor motion is not detected.

2.10 FINISHES

A. Surface preparation, factory prime, field prime and finish coats as specified in Section 09960.

B. Stainless steel components: Chemically clean all exterior welds to remove discoloration and glass-blast all exterior stainless steel surfaces only to a uniform finish.

C. Spiral: Shop primer coating following sandblasting.

D. Torque bracket: Epoxy coating.

E. Drive shaft: Zinc Plate Shaft (Rust inhibitor coating).

PART 3 EXECUTION

3.01 EXAMINATION

A. MANUFACTURER shall coordinate with installing Contractor and field verify the actual dimensions required to construct the equipment prior to fabrication.

3.02 INSTALLATION

A. Contractor shall install screw conveyors in accordance with manufacturer's recommendations:
   1. All field welds shall be chemically cleaned to remove discoloration by Contractor.

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

3.03 SHOP TESTING

A. Conveyors, in their entire length, shall be inspected and operated in the shop with the actual drive unit for the project:
   1. Unit shall be fully assembled with tack welds at the factory and test run for 15 minutes to check for equipment tolerances and proper operation.
   2. Conveyors shall be corrected as necessary.
   3. Prior to shipment, the tack welds will be broken apart and conveyors suitably prepared for shipment.
   4. A recorded video of the test shall be submitted to the Engineer for record purposes.

3.04 FIELD QUALITY CONTROL

A. Testing: Perform operational and functional testing as specified in Section 01756 and Section 15958.

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

C. Manufacturer's representative:
   1. Testing: Provide services of factory-trained representative to observe and advise the Contractor during field quality control testing.
   2. Field service:
      a. The manufacturer shall include in the cost of the equipment 1 trip of 2 days to the site.
      b. A qualified field-service engineer shall spend 8 hours at the site each trip.
      c. The field service engineer shall be responsible for checking the installation and equipment start-up.
   3. Conveyor manufacturer shall provide four hours of training on the operation and maintenance of the conveyors.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

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

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

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

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
   4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   9. B61 - Standard Specification for Steam or Valve Bronze Castings.
   10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
   11. B505 - Standard Specification for Copper Alloy Continuous Castings.
   12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   14. F594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI).

F. Occupational Safety and Health Administration (OSHA).

G. Unified Numbering System (UNS).

1.03 DEFINITIONS

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

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

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

D. 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.

E. Rotational speed: Same as rotational frequency.

F. 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.

G. Critical speed: Same as critical frequency.

H. 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.

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

1.04 DESIGN REQUIREMENTS

A. General:
   1. Product requirements as specified in Section 01600 - Product Requirements.
   2. Project conditions as specified in Section 01610 - Project Design Criteria.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
   4. 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.
   5. Vibration considerations:
      a. Resonant frequency:
         1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
         2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
      b. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.
   6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

B. Power transmission systems:
   1. 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 service factor of 1.5 or greater in accordance with manufacturer recommendations:
      a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
      b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.

C. Equipment mounting and anchoring:
   1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
   4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, and other loads as required for proper operation of equipment.
      a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
         1) The operating weight and location of the centroid of mass for the equipment.
         2) Forces and overturning moments.
         3) Shear and tension forces in equipment anchorages, supports, and connections.
         4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
   5. Anchorage of equipment to concrete or masonry:
      a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
      b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
         1) Adjust bolts to final location and secure the sleeve.
   6. Anchorage of equipment to metal supports:
      a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
   7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

1.05 SUBMITTALS

A. As specified in Section 01600 - Product Requirements.

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. Nameplate data.
      h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
   2. Gear reduction units:
      a. Engineering information in accordance with applicable AGMA standards.
      b. Gear mesh frequencies.

C. Shop drawings:
   1. Drawings for equipment:
      a. Drawings that include 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, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
   3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing 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 setpoints for all controls furnished.

D. Calculations:
   1. Mechanical:
      a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
      b. Substantiate that operating rotational frequencies meet the requirements of this Section.
      c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
         1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
         2) Results of analysis including first and second critical frequencies of system components and complete system.
      d. Calculations shall be signed and stamped by a licensed engineer.

2. Drinking water:
   a. If applicable, conform to the requirements of Section 01600 - Product Requirements for materials in contact with drinking water.

E. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operating and Maintenance Data.
   2. Equipment with bearings:
      a. Include manufacturer and model number of every bearing.
      b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.

F. Commissioning submittals: As specified in Section 01756 - Commissioning.

G. Project closeout documents: As specified in Section 01770 - Closeout Procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

B. Ferrous materials:
   1. Steel for members used in fabrication of assemblies: ASTM A36.
   2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
   3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
   4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
   5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
   6. Stainless steel:
      a. As specified in Section 05120 - Structural Steel.
      b. In contact or within 36 inches of water: Type 316 or 316L.
      c. In sea air environment: Type 316 or 316L.
      d. Other locations: Type 304 or 304L.
      e. Source cleaning and passivation as specified in Section 05120 - Structural Steel.

C. Non-ferrous materials:
   1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
   2. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520, C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
   3. Aluminum: As specified in Section 05140 - Structural Aluminum.

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

E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03600 - Grouting.

2.02 ANCHORS AND FASTENERS

A. Mechanical anchoring to concrete and masonry:
   1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
      a. Type 316 stainless steel.

B. High-strength fasteners:
   1. As specified in Section 05120 - Structural Steel.

C. Flange bolts:
   1. As specified in Section 15052 - Common Work Results for General Piping.

D. Mechanical assembly fasteners:
   1. Stainless steel:
      a. High-temperature service or high-pressure service:
         1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
         2) Nuts: ASTM A194, Grade 8, heavy hex.
         3) Washers: Alloy group matching bolts and nuts.
      b. Low-temperature service:
         1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
         2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
         3) Washers: Alloy group matching bolts and nuts.
      c. General service:
         1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
         2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
         3) Washers: Alloy group matching bolts and nuts.

2.03 SHAFT COUPLINGS

A. General:
   1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.

B. Shaft couplings for close-coupled electric-motor-driven equipment:
   1. Use for:
      a. Equipment 1/2 horsepower or larger.
      b. Reversing equipment.
      c. Equipment subject to sudden torque reversals or shock loading:
      d. Examples:
         1) Reciprocating pumps, blowers, and compressors.
         2) Conveyor belts.

2. Manufacturers: One of the following or equal:
   a. Lovejoy.
   b. T.B. Woods.
3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
4. Manufacture flexible component of coupling from synthetic rubber or urethane.
5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
6. Do not allow metal-to-metal contact between driver and driven equipment.

C. Shaft couplings for direct-connected electric-motor-driven equipment:
1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
2. Manufacturers: One of the following or equal:
   a. Rexnord.
   b. T.B. Woods.
3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
4. Provide flexible connecting element of rubber and reinforcement fibers.
5. Provide service factor of 2.0.
6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

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

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
1. Includes any engine-driven equipment.

2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

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

c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water).
e. Double seal applications: Plan 54 (External seal water).

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, equivalent product.
2. Drinking water service:
a. Asbestos free.
b. Material: Braided PTFE (Teflon).
c. Manufacturers: One of the following or equal:
1) Chesterton, 1725.
2) John Crane, equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
1. Provide seal types meeting the following requirements:
a. Balanced hydraulically.
b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
c. O-ring: Viton 747.
d. Gland: Type 316L stainless steel.
e. Set screws: Type 316L stainless steel.
f. Faces: Reaction bonded, silicon carbide.
g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
2. Cartridge-type single mechanical:
a. Manufacturers: One of the following or equal:
1) Chesterton, S10.
2) John Crane, 5610 Series.
3. Cartridge-type double mechanical: Manufacturers:
a. One of the following or equal:
1) Chesterton, S20.
2) John Crane, 5620 Series.
4. Split-face single mechanical: Manufacturers:
a. One of the following or equal:
1) Chesterton, 442.
2) John Crane, 3740.
5. Cartridge-type flushless mechanical:
a. Manufacturers: One of the following or equal:
1) Chesterton, 156.
2) John Crane, 5870.

2.05 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.

2.06 BELT DRIVES

A. Sheaves:
  1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
  2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
  3. Statically balanced for all; dynamically balanced for sheaves that operate at a 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.
  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. Manufacturers: One of the following or equal:
  1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
  2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.07 BEARINGS

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

B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
  1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.

2. Provide an external oil cooler when required to satisfy the specified operating conditions:
    a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
    b. Equip oil cooler with a filler pipe and external level gauge.

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

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.08 MOTORS

A. As specified in Section 16405.

2.09 GEAR MOTORS

A. Motors as specified in Section 16405.

B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.

C. Manufactures: One of the following or equal:
    1. Baldor Electric Company.
    2. Bodine Electric Company.

2.10 VENDOR CONTROL PANELS

A. As specified in Section 17000.

2.11 EQUIPMENT SUPPORT FRAMES

A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4-inch.

2.12 PIPING AND VALVES

A. Piping as specified in Section 15052 - Common Work Results for General Piping.

B. Valves as specified in Section 15110 - Common Work Results for Valves.

2.13 SAFETY EQUIPMENT

A. Safety guards:
   1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
   2. Requirements:
      a. Allow visual inspection of moving parts without removal.
      b. Allow access to lubrication fittings.
      c. Prevent entrance of rain or dripping water for outdoor locations.
      d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
   3. Materials:
      a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
      b. Fasteners: Type 304 stainless steel.

B. Insulation:
   1. 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.
   2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.

C. Warning signs:
   1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
   2. Mount warning signs with stainless steel fasteners at equipment.

2.14 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.

B. Performance requirements: Minimum spring deflection of 1-inch under static load and capable of limiting transmissibility 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 A536 Grade CS-45-12.
   2. Spring steel: ASTM A125.

2.15 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.

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

D. Text:
   1. Manufacturer’s name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
   2. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class per applicable standards.
   3. Include for pumps:
      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. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

2.16 SHOP FINISHES

A. Provide appropriate factory coatings as specified in Section 09960 - High-Performance Coatings.
   1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

2.17 SPECIAL TOOLS

A. Supply 1 set of special tools as specified in Section 01600 - Product Requirements.

2.18 SOURCE TESTING

A. Testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Motors: As specified in Section 16405.
   3. Vendor control panels: As specified in Section 17000.

2.19 SHIPPING

A. As specified in Section 01600 - Product Requirements.

B. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION

A. As specified in Section 01600 - Product Requirements.

B. Inspect fasteners for proper torques and tightness.

C. Storage:
   1. Bearings:
      a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes:
      a. Inspect to verify integrity of protection from rust.

D. Protection:
   1. Equipment Log shall include description of rotation performed as part of maintenance activities.

3.02 INSTALLATION

A. Field measurements:
   1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

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

C. 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.

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

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

F. Lubrication lines and fittings:
   1. Support and protect lines from source to point of use.

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.

G. Alignment of drivers and equipment:
1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
   a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
   b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   a. Allow minimum 48 hours for grout to harden.
   b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   c. Correct alignment as required.
6. After functional testing is complete, dowel motor or drivers and driven equipment:
   a. Comply with manufacturer's instructions.

H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600 - Grouting.
   a. Non-shrink epoxy grout required only when indicated on the Drawings.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
3. Install grout only after:
   a. Equipment is leveled and in proper alignment.
   b. Piping connections are complete and in alignment with no strain transmitted to equipment.
4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.

5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
   a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
   b. Use suitable number and size of jack screws.
   c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
   d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
   e. Place and cure grout as specified in Section 03600 - Grouting.
   f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
      1) Provide jack screws to Owner for future use.
   g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
   h. Fill holes where jack screws have been removed with grout.
   i. Cure as specified in Section 03600 - Grouting.
6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
   a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
   b. Place and cure grout as specified in Section 03600 - Grouting.
   c. Remove wedges or shims.
   d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
   e. Fill voids where wedges and shims have been removed with grout.
   f. Cure as specified in Section 03600 - Grouting.
7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
   a. Metal in contact with grout: Grit blast to white metal finish.
   b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
8. Preparation of concrete equipment foundation for grouting:
   a. Rough concrete surfaces in contact with grout.
   b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
   c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
   d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.
9. Forms and header boxes:
   a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
   b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
   c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.

10. Grout placement requirements:
    a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
        1) Conform to grout manufacturer’s temperature requirements.
    b. Pour grout using header box.
    c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
    d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
    e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
    f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
    g. Cure as specified in Section 03600 - Grouting.

I. Field welding:
    1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
    2. Shielded arc welding.

J. Field finishes:
    1. Protect motors.
    2. Clean equipment.
    3. Apply primer and coating systems as specified in Section 09960 - High-Performance Coatings requirements.

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

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

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

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
    1. Mechanical equipment: Level 1 tests as specified in Section 15958 - Mechanical Equipment Testing.
    2. Motors: As specified in Sections 16405 and 16950.
    3. Vendor control panels: As specified in Section 17000.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic piping materials and methods.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01140 - Work Restrictions.
      b. Section 09960 - High-Performance Coatings.
      c. Section 15061 - Pipe Supports.
      d. Section 15211 - Ductile Iron Piping: AWWA C151
      e. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

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

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

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

1.03 DEFINITIONS

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

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

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

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

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

1.04 SUBMITTALS

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

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

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

2.02 LINK TYPE SEALS

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

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

2.03 FLANGE BOLTS

A. Ductile iron pipe:
   1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures and where pressures do not exceed 150 pounds per square inch shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.

2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A 193, Grade B7.
3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. 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. Lubricant for stainless steel bolts and nuts:
1. Chloride-free.
2. Manufacturers: One of the following or equal:
a. Huskey FG-1800.

2.04 GASKETS

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

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

C. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to or less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
   2. Material: 0.125-inch thick Viton rubber.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

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

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

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

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

A. General:
  1. Piping drawings:
     a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
     b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
        1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
  2. Piping alternatives:
     a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
     b. Alternative pipe ratings:
        1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
        2) Piping of different material may not be substituted in lieu of specified piping.
     c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
     d. For flanged joints, where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
  3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

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

b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. Support piping: As specified in Sections 15061:
a. Do not transfer pipe loads and strain to equipment.
4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
5. Assemble piping without distortion or stresses caused by misalignment:
a. Match and properly orient flanges, unions, flexible couplings, and other connections.
b. Do not subject piping to bending or other undue stresses when fitting piping.
c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
e. Alter piping assembly to fit, when proper fit is not obtained.
f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

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

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

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

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

H. Connections to in-service piping:
   1. As specified in Section 01140.

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

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

3.03 CLEANING

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

B. Cleaning potable water piping:
   1. Flush and disinfect potable water piping.

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

3.04 PIPING SCHEDULE

A. Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as 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:

ASP	Asphaltic
BFPF	Belt Filter Press Feed
B&S	Special case
B&SP	Bell & Spigot
BSP	Black Steel Pipe
CI	Cast iron
CISP	Cast Iron Soil Pipe
CD	Chemical Drain
CE	Ceramic Epoxy
CND	Condensate Drain
CL	Class, followed by the designation
CM	Cement Mortar
CMP	Corrugated Metal Pipe
CPVC	Chlorinated Polyvinyl Chloride
CTP	Coal Tar Pitch
CU	Copper Tubing
DIP	Ductile iron piping
FL	Flanged
HTC	High Temperature Coating
FRP	Fiberglass Reinforced Pipe
GA	Gauge, preceded by the designation
GE	Grooved end joint
GL	Glass Lined
GSP	Galvanized Steel Pipe
HPC	High Performance Coating

HSE	High Solids Epoxy
HSEP	High Solids Epoxy and Polyurethane
MJ	Mechanical Joint
NPS	Nominal pipe size, followed by the number in inches
PE	Polyethylene
PEE	Polyethylene Encasement
PJ	Push on Joint
psi	pounds per square inch
psig	pounds per square inch gauge
PTW	Plastic Tape Wrap
PVC	Polyvinyl Chloride
Restr	Reinforced Concrete Pipe
RCP	Restrained
RDL	Roof Drain Leader
SCH	Schedule, followed by the designation
SCRD	Screwed
SDR	PVC - SDR Series Pipe
SST	Stainless steel
SW	Solvent Weld
TW	Tape Wrap
VE	Chemical Vent
VCP	Vitrified clay piping
WLD	Welded

PIPING SCHEDULE									
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**
WAS	Waste Activated Sludge								
	Above Ground	4	DIP	Thickness CL 53 (min)	15211	FL	75 psig/HH	CE[1]	HSEP
WW or RW	Washwater								
	Below Ground	10	DIP	Thickness CL 53 (min)	15211	Restrained MJ	50 psig/HH	Cement Lined	Per manufacturer
	Above Ground	1 - 6	PVC (INSIDE BFP ROOM)	80 sch	15249	SW	50 psig/HH		
DR	Drain								
	Above Ground	1 - 10	PVC	SDR 26	15247	SW	10 psig/LH	None	None

Notes:
1. Contractor shall provide PROTECTO 401 Ceramic Epoxy or Permite Permox PCS-9043 Type II Glass Flake Epoxy lining for ductile iron pipes.

END OF SECTION

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SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances and conveyors in the belt filter press room.

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 05120 - Structural Steel.
   b. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
2. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturer's Standardization Society (MSS):
1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

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 MATERIALS

A. General:
1. 316 Stainless steel.
   a. Fabricate as specified in Section 05120.
   b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A 380 or A 967.
    1) Passivation treatments using citric acid are not allowed.
d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas and inside the belt filter press room:
    1. Type 316L Stainless Steel.

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

2.02 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
    1. Manufacturers: One of following or equal:
        a. For stainless steel piping:
            1) Bergen-Power, Figure 133.
            2) Nibco-Tolco, Figure 103.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 140.
            2) Bergen-Power, Figure 133.
            3) Cooper B-Line Systems, Inc., Figure B3205.

B. 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. For stainless steel piping:
            1) Bergen-Power, Figure 94.
            2) FM Stainless Fasteners.
        b. For steel and ductile iron piping:
            1) Anvil International, Figure 146.
            2) Bergen-Power, Figure 94.

C. Eye bolts:
    1. For stainless steel piping:
        a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
    2. For all other piping, unless indicated on the Drawings:
        a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 101.
            2) FM Stainless Fasteners.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 278.
            2) Bergen-Power, Figure 93.
            3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1C.I.
         2) Bergen-Power, Figure 100SS.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 97.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc, Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure 100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1A.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 300.
         2) Bergen-Power, Figure 100EL.
         3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, 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. For stainless steel piping:
         1) Nibco-Tolco, Figure 324.
         2) Cooper B-Line Systems, Inc., Figure B3110.
         3) FM Fasteners, Figure 81.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 181.
         2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) FM Stainless Fasteners, Figure 71.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 171.
         2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 30M.
            2) Cooper B-Line Systems, Inc., Figure B3066.
            3) FM Stainless Fasteners, Figure 98.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 195.
            2) Cooper B-Line Systems, Inc., Figure B3066.

K. Standard U-bolt: MSS SP-58, Type 24:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 110.
            2) Cooper B-Line Systems, Inc., Figure B3188.
            3) FM Stainless Fasteners, Figure 37.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 137.
            2) Bergen-Power, Figure 283.
            3) Cooper B-Line Systems, Inc., Figure B3188.

L. Riser clamps: MSS SP-58, Type 8:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure B3373.
            2) FM Stainless Fasteners, Figure 61.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 261.
            2) Bergen-Power, Figure 126.
            3) Cooper B-Line Systems, Inc., Figure B3373.

M. Pipe clamps: MSS SP-58, Type 4:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 4.
            2) Cooper B-Line Systems, Inc., Figure 3140.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 212.
            2) Bergen-Power, Figure 175.
            3) Cooper B-Line Systems, Inc., Figure B3140.

N. Adjustable offset pipe clamp:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 4.
            2) Cooper B-Line Systems, Inc., Figure B3149.
            3) FM Stainless Fasteners, Figure 63.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 100.
            2) Cooper B-Line Systems, Inc., Figure B3149.

O. Offset pipe clamp:
1. Manufacturers: One of the following or equal:
   a. For stainless steel piping:
      1) Nibco-Tolco, Figure 8.
      2) Cooper B-Line Systems, Inc., Figure 3148.
   b. For all other piping, unless indicated on the Drawings:
      1) Anvil International, Figure 103.
      2) Cooper B-Line Systems, Inc., Figure B3148.

P. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
1. Manufacturers: One of the following or equal:
   a. For stainless steel piping:
      1) Nibco-Tolco, Figure 318.
      2) FM Stainless Fasteners, Figure 59.
   b. For all other piping, unless indicated on the Drawings:
      1) Anvil International, Figure 259.
      2) Bergen-Power, Figure 125.
      3) Cooper B-Line Systems, Inc., Figure B3090.
   b. Threaded pipe stand support stanchion. Match pipe support material.
      1) Anvil International, Figure 63T.
      2) Bergen-Power, Figure 138.
      3) Cooper B-Line Systems Inc., Figure B3088ST.

Q. Spring hangers:
1. Manufacturers: One of the following or equal:
   a. For stainless steel piping:
      1) Bergen-Power, Figure 920.
   b. For all other piping, unless indicated on the Drawings:
      1) Anvil International, Figure B-268, Type G.
      2) Bergen-Power, Figure 920.

R. One hole pipe clamps:
1. Manufacturers: One of the following or equal:
   a. For stainless steel piping:
      1) Not used.
   b. For all other piping:
      1) Anvil International, Figure 126.
      2) Carpenter & Paterson, Figure 237S.

S. Welded beam attachment: MSS SP-58, Type 22:
1. Manufacturers: One of the following or equal:
   a. For stainless steel piping:
      1) Nibco-Tolco, Figure 304.
      2) Cooper B-Line Systems, Inc., Figure 3083.
   b. For all other piping, unless indicated on the Drawings:
      1) Anvil International, Figure 66.
      2) Bergen-Power, Figure 113A or 113B.
      3) Cooper B-Line Systems, Inc., Figure B3083.

T. Heavy pipe clamp: MSS SP-58, Type 4:
  1. Manufacturers: One of the following or equal:
    a. For stainless steel piping:
      1) Nibco-Tolco, Figure 4H.
    b. For all other piping, unless called out otherwise on the Drawings:
      1) Anvil International, Figure 216.
      2) Bergen-Power, Figure 298.

U. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
  1. Manufacturers: One of the following or equal:
    a. For stainless steel piping:
      1) Nibco-Tolco, Figure 426.
    b. For all other piping, unless indicated on the Drawings:
      1) Anvil International, Figure 257, Type 3.
      2) Cooper B-Line Systems, Inc., Figure B3893.

V. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: 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. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

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

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

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

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

G. Suspend pipe hangers from hanger rods and secure with double nuts.

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

I. Use adjustable ring hangers or adjustable clevis hangers, for 4 inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, 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.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

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

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

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

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

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

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 plumbing code as specified in Section 01410.

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

W. Coat support system components as specified in Section 09960.

END OF SECTION

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SECTION 15075

EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

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

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01600 - Product Requirements.
      c. Section 01770 - Closeout Procedures.
      d. Section 09960 - High-Performance Coatings.

1.02 SUBMITTAL

A. Submit as specified in Section 01330.

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

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

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

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

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

2.02 SPECIAL ITEMS

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

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

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

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

3.02 PREPARATION

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

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

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

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

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01600 - Product Requirements.
      c. Section 01770 - Closeout Procedures.
      d. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

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

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

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

PART 2 PRODUCTS

2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

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

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

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

      b. Marker colors:

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

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

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Company, Branford, CT.
      b. T. Christy Enterprises, Inc.
   2. Material:
      a. Polyethylene tape for prolonged underground use.
      b. Minimum tape thickness: 4 mils.

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

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

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

2.03 VALVE IDENTIFICATION

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

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

3.02 PREPARATION

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

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

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

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

B. Color code:
   1. Paint all piping with colors as scheduled in Piping Color Code and Marker Schedule.

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

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

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

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

3.04 BURIED PIPING IDENTIFICATION

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

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.

3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
    a. Twisting the wires together is not acceptable.

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

3.05 APPLICATION

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

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

C. Provide piping marker letters and colors as scheduled.

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

3.06 PIPING COLOR CODE AND MARKER SCHEDULE

A. All light piping paint is also by Sher-Cryl HPA Protective & Marine Coatings. Coordinate with OWNER for their standards.

Sherwin Williams Custom Match to Panton Purple 522-C 1 Gallon of Sher-Cryl					
CC#	Color Cast	OZ	32	64	128
B1	Black	-	21	-	1
L1	Blue	-	10	1	1
R3	Magenta	2	16	1	1
R2	Maroon	-	1	1	-
W1	White	2	16	-	-

Service Fluid	**Pipe Color**
Drain	Charcoal
Instrumental Air	Purple
Sample	Green
Sanitary Drain	Charcoal
Vent Pipe	Yellow

Service Fluid	Pipe Color
Wash Water (W3)	Medium Blue
Waste Activated Sludge, Thickened Sludge, Sludge Transfer	Tempest Brown
Polymer	Purple
Potable Water	Blue
Non-potable Water	Blue with black bands

Letters	Color of Bands	Color of Letters
Finished or Potable (cold)	None	Black
Nonpotable or Raw	Dark Gray	Black
Service Water (lines downstream from backflow prevention unit	White	Red
Sample	Black	White
Polymer	Dark Green	Black
Low Pressure Air - Stainless Steel Pipe	None	Black
Compressed Air	None	Black
Waste Activated Sludge	None	White

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

B. Related sections:
1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330 - Submittal Procedures.
   b. Section 09960 - High-Performance Coatings.
   c. Section 17000 - Instrumentation and Controls
   d. Section 15211 - Ductile Iron Piping: AWWA C151.

1.02 REFERENCES

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

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

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

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

1.03 DESIGN REQUIREMENTS

A. Pressure rating:
1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.

2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

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

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

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

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

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY STORAGE AND HANDLING

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

PART 2 PRODUCTS

2.01 MATERIALS

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

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

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

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

2.02 INTERIOR PROTECTIVE LINING

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

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

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

5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

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

2.03 UNDERGROUND VALVES

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

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. Neenah Foundry Company.

2.05 VALVE OPERATORS

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

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

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.

2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

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

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

PART 3 EXECUTION

3.01 EXAMINATION

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

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

3.02 INSTALLATION

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

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

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

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

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

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

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

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

3.03 VALVE SCHEDULE

A. See Valve Schedule as shown on the drawings.

END OF SECTION

SECTION 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Petroleum Institute (API):
   1. 6D - Specification for Pipeline Valves (Steel Gate, Plug, Ball, and Check Valves) - Gate ValvesA; Plug Valves; Ball Valves; Check Valves.

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

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

D. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SYSTEM DESCRIPTION

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

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

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, 6-INCH SIZE AND LARGER

A. Manufacturers: One of the following:
   1. Valmatic.
   2. DeZURIK.
   3. Approved Equal.

B. General:
   1. Type: Non-lubricated, **resilient 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 A48 cast iron with 400 series Monel seats (metal seated valves only) and integrally cast bronze bushed trunnions.
   2. Ball: Type 304 or 316 stainless steel.
   3. Seats: 300 series stainless steel {metal seated valves}.
   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. Conbraco Industries, Inc., Apollo Valves.
   2. Flow-Tek, Inc.
   3. Metso Automation/Jamesbury.
   4. 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 inches.
         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 - Common Work Results for General Piping.
4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
5. Seats: PTFE.
6. Stem seals: PTFE or Viton.
7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.03 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
1. Asahi America.
2. Chemtrol Division, NIBCO, Inc.
3. Georg Fischer Piping Systems.
4. Hayward Flow Control.
5. Plast-O-Matic Valves, Inc.

B. General:
1. Type: Non-lubricated and capable of sealing in either flow direction.
2. End connections: True union; solvent or heat welded to piping.
3. Operator handle: Lever.

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

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.
   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.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-lubricated plug valves.
   2. Lubricated plug valves.

B. Valves have to meet AIS requirements as required by the FDEP SRF loan requirements.

C. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 09960 - High-Performance Coatings.
      c. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C606 - Grooved and Shouldered Joints.
   2. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.

B. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 NON-LUBRICATED PLUG VALVES

A. Manufacturers:
   1. DeZurik, "PEF."
   2. Valmatic.
   3. Henry Pratt.
   4. No Substitutions.

B. Design:
   1. Type: Rectangular or round ported Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly. Shaft seals shall be of the multiple V-ring type with a packing gland follower. Shaft seals shall be externally adjustable and repackable under pressure without removing the actuator or bonnet from the valve. An air gap shall exist between shaft packing and bottom of actuator for visual inspection, adjustment or complete replacement of packing without disturbing any portion of the valve or actuator except the packing gland follower. Alternatively, valves shall utilize self-adjustable packing. Valves utilizing O-ring seals or non-adjustable packing shall not be acceptable.
   5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.
   8. Plug design: Rectangular port is full 100 percent of standard pipe area including straight through body design with flushing port to maximize flow capacity and minimize head loss and clogging with round port, especially on the return activated sludge (RAS) and waste activated sludge (WAS) lines from the secondary clarifiers as indicated on the drawings.

C. Materials:
   1. Body and plug: ASTM A 126, Class B, cast-iron body and ASTM A 536, Grade 65-45-12, ductile iron plug, with plug face Neoprene material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.

5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.
6. Grit Excluder - PTFE (Teflon).

2.02 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4 inch nominal size and smaller with a lever operator.
   2. Equip valves 6 inch nominal size and larger with a worm gear operator.

2.03 COATING

A. Coat interior metal surfaces as specified in Section 15110.

B. Coat exterior metal surfaces as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and the manufacturer's instructions.

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

C. Lubrication: Lubricate plug valves and fill extended lubricant pipes with lubricant suitable for service intended.

D. Install valves so that in the open position the plug is located in the top half of the valve body.

END OF SECTION

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SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Piping specialties including:
   1. Flexible rubber connections.
   2. Rubber expansion joints.
   3. Transition Fittings.
   4. Pipe saddles for ductile iron pipe.
   5. Tapping sleeves.
   6. Pressure gauges.

B. Related Sections:
   1. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

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

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

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

D. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Product Data:
   1. Manufacturer's certificate attesting successful performance of specified tests.
   2. Shop drawings detailing dimensions and materials. Provide weights for each size of ball type flexible expansion joint used on the project.
   3. Manufacturer's published installation instructions.
   4. Operation and maintenance manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Bellows Type Expansion Joints and Vibration Control Joints:
   1. Protect joints against damage during packing, shipping, installation, and also during pressure test.
   2. Lock expansion joints against movement until pressure tests are completed.
   3. Replace damaged expansion joints with new and undamaged expansion joints.

B. Ball-Type Flexible Expansion Joints:
   1. Protect sliding and rotating surfaces against damage during packing, shipping, and installation.
   2. Lock expansion joints against movement until pressure tests are completed.

PART 2 PRODUCTS

2.01 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Company, Type 150 Vibraflex.
   2. Red Valve Company, Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8 inch thick neoprene rubber tube with full faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.02 RUBBER EXPANSION JOINTS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Company, Style 500 or 700.
   2. Red Valve Company, Inc., Type J-1.

B. Provide rubber expansion joints complete with control units and split retaining rings.

C. Design:
   1. Material: Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.
   2. Expansion Rings, Suitable for Pressures of at Least 125 Pounds per Square Inch Gauge, Except as Follows:
      a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 90 pounds per square inch gauge, pressure and minimum 30 inches mercury vacuum.
      b. Split retaining rings, galvanized.
      c. Ends of expansion joints, 150 pound ANSI flanges with drilling to match that of the piping.

D. Rubber Expansion Joints for Blowers: Butyl type rubber formulated for service application and for maximum temperature of 250 degrees Fahrenheit, suitable for minimum 40 pounds per square inch gauge pressure, and minimum 15 inches mercury vacuum.

2.03 TRANSITION FITTINGS

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

B. Materials:
   1. Slip Socket: Schedule 80 PVC.
   2. Collar: 316 Stainless Steel.
   3. Threaded Insert: 316 Stainless Steel.

2.04 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.
   3. Gaskets: Rubber.

2.05 TAPPING SLEEVES

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

B. Materials:
   1. Tapping Sleeves: Steel construction.
   2. Bolts and Nuts: Type 304 stainless steel.
   3. Nuts: Teflon coated.
   4. Gaskets: Rubber.
   5. Size of Tapped Boss: As indicated on the Drawings.

2.06 PRESSURE GAUGES

A. Design:
   1. Provide dual-range, liquid filled gauges with ranges as indicated on the Drawings.
   2. Size: As follows, unless otherwise indicated on the Drawings or specified:
      a. For 1-Inch Pipe and Larger: 4-1/2 inch diameter.
      b. For Smaller than 1-Inch Pipe: 2-1/2 inch diameter.
   3. Provide gauges with Type 316 stainless steel, wetted parts, phenolic cases with threaded ring, except for panel mounting, in which case provide gauge with front flanged aluminum case with threaded ring. Apply black epoxy coating to cases.
   4. Provide case fitted with a rupture disc, which shall relieve out the back of the case.

5. Window: Shatterproof glass or high temperature acrylic.
6. Provide gauges with Type 316 stainless steel socket and bellows or bourdon tube, depending on pressure range.
    a. Where the maximum pressure is less than or equal to 15 pounds per square inch, the gauge shall use bellows as the measuring element.
    b. Where the maximum pressure is greater than 15 pounds per square inch, the measuring element shall be a bourdon tube.
7. Socket Tips:
    a. Socket Tips for Bellows and Bourdon Tube: Type 316 Stainless steel.
    b. Size: 1/2 inch for 4-1/2 inch diameter gauges, 1/4 inch for 2-1/2 inch diameter gauges.
8. Mount gauges on diaphragm seals where indicated on the Drawings.
    a. Provide diaphragm seals with Type 316 stainless steel top housing, bottom housing and bolt assemblies, except as follows:
        1) Sodium hypochlorite and ferric chloride service: Provide Titanium diaphragm seal bottom housing.
        2) Sodium hydroxide service: Provide Monel diaphragm seal bottom housing.
        3) Hydrochloric acid: Provide Hastelloy C diaphragm seal bottom housing.
    b. Fit bottom housing with a 1/4 inch flushing connection with Type 316 stainless steel nipple and shutoff cock.
        1) Sodium hypochlorite and ferric chloride service: Provide PVC shutoff cock.
    c. Diaphragm Seal: Removable.
        1) For pressure less than or equal to 15 pounds per square inch, provide viton diaphragm seal.
        2) For pressures greater than 15 pounds per square inch, provide Type 316 stainless steel diaphragm seal.
        3) For sodium hypochlorite, ferric chloride, and hydrochloric acid applications, provide Tantalum diaphragm seals.
        4) For sodium hydroxide application, provide Monel diaphragm seals.
    d. Fit diaphragm seal gauge assembly with a snubber.
        1) Snubber shall have porous metal disc sized to dampen pressure fluctuations in the filled system.
        2) Snubber: Stainless steel.
        3) Snubber filter disc shall be sized to prevent the gauge from pulsating.
        4) Provide diaphragm seal gauge assemblies filled with silicon, except as follows:
            a) For sodium hypochlorite, ferric chloride, sodium hydroxide, and hydrochloric acid, provide diaphragm seal gauge assemblies filled with halocarbon.
9. Pressure gauges, except gauges with diaphragm seals, shall have pulsation dampeners installed between the gauge and the shut-off valve.
    a. Pulsation Dampeners: Stainless steel.

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

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

PART 3 EXECUTION

3.01 INSTALLATION

A. Expansion Joints for Steam Cleaned Piping:
1. Install no less than one expansion joint in a run of steam cleaned piping which exceeds 20 feet in length. Do not exceed 200 feet in spacing of expansion joints.
2. Install expansion joints in steam cleaned piping between anchors.

B. Vibration Control Joints:
1. Install vibration control joints at piping connections to or from mechanical equipment to prevent transmitting equipment vibration through the piping system.

C. Transition Couplings
1. Application:
    a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
2. Install transition-coupling products specifically designed and manufactured for that application.

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

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

F. 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: Flexible couplings, flanged coupling adapters.

B. Related Sections:
   1. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

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

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

C. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Shop drawings detailing dimensions and materials.

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

D. Manufacturer's published installation instructions.

PART 2 PRODUCTS

2.01 PIPE COUPLINGS IN DUCTILE IRON PIPING

A. Flexible Couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser Industries, Style 153.
      b. Romac Industries, Inc., Style 501.
      c. Smith-Blair, Inc., Series 441.
   2. Materials:
      a. Center Sleeve: Ductile iron, ASTM A536.
      b. Follower Flanges: Ductile iron, ASTM A536.

c. Bolts and Hex Nuts:
    1) Aboveground: High strength, low alloy steel.
    2) Buried and Underwater: Type 316 stainless steel.
3. Coating and Lining: Provide product with shop-applied primer which is compatible with finish coating to be applied in the field.
4. Center Sleeve Dimensions: Provide center sleeves with lengths in accordance with following table:

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

B. Flanged Coupling Adapters, 12-inch size and smaller:
1. Manufacturers: One of the following or equal:
    a. Dresser Industries, Style 127.
    b. Romac Industries, Inc., Style FCA501.
    c. Smith-Blair, Inc., Series 912.
2. Materials:
    a. Flanged Body: Ductile iron, ASTM A126 or ASTM A536.
    b. Follower Ring: Ductile iron, ASTM A536.
    c. Bolts and Hex Nuts:
        1) Aboveground: High strength, low alloy steel.
        2) Buried and Underwater: Type 316 stainless steel bolts.
3. Flange Design: In accordance with AWWA Class D with ANSI 150 pound drilling.
4. Coating and Lining: Provide product with shop-applied primer which is compatible with finish coating to be applied in the field.

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

D. Restrained Flanged Coupling Adaptor:
1. Manufacturers: One of the following or equal:
    a. Romac Industries, Inc., Style DJ400.
    b. Smith-Blair, Inc., Series 975.

2. Materials:
    a. Flanged Spool: AWWA Class D steel ring flange, compatible with ANSI Class 125 and 150 bolt circles. Pipe shall be Schedule 40 ASTM A53 for sizes 3 inches to 12 inches. Pipe shall be ASTM A36 for sizes 14 inches to 72 inches.
    b. End Ring and Body: For sizes 3 inches to 12 inches, ASTM A536 ductile iron. For sizes 14 inches to 72 inches, Steel ASTM A36.
    c. Bolts and Hex Nuts: High strength, low alloy steel.
    d. Tie Rods: High tensile steel per ASTM A193 grade B7.
3. Coating and Lining: Fusion bonded epoxy, NSF 61 certified.

2.02 SPLIT-SLEEVE TYPE COUPLING

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

B. Construction: Couplings selected shall be designed for the type, size and working pressure of the pipe with which they are to be used.
1. Couplings are bolted, split-sleeve type and consist of these basic components:
    a. One or two-piece housing.
    b. Gasket assembly
    c. Bolts, nuts, and end rings required for pipe restraint.
2. Coupling shall be manufactured from ASTM A 36 Carbon Steel. The coupling shall be of a double arch cross section, which closes around pipe ends (with steel end rings for thrust restraint as required). As the coupling closes, it confines the elastomeric gasket beneath the arches of the sleeve to create the radial seal. The axial seal is affected at the closure plates as the bolts pull the coupling snug around the pipe. The coupling shall permit a degree of angular pipe deflection, flexibility, contraction, and expansion (limited by the thrust rings when required). Couplings shall be epoxy-coated on the inner diameter and outer diameter prior to delivery. Buried couplings shall receive additional protection against corrosion that matches the pipe as given in Section 09960. Bolts and nuts shall conform to the requirements of Section 05500.

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

D. Gaskets: The sealing members are comprised of two (2) "O" ring gaskets and an elastomeric sealing pad bonded to the integral sealing plate. Internal pressure is not required to affect the seal. For water service, the gasket supplied may be Isoprene or Buna-N conforming to ASTM D-2000 for the design pressure within the temperature range of minus 20 to 180 degrees Fahrenheit. Elastomers shall have properties as designated by ASTM D-2000.

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

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

2.03 FLEXIBLE COUPLINGS FOR STAINLESS STEEL PIPING

A. Manufacturers:
   1. Dresser Industries, Style 38, or approved equal.

2.04 GASKETS FOR FLEXIBLE COUPLINGS AND FLANGED COUPLING ADAPTERS

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

2.05 EXTERIOR COATINGS - UNDERGROUND AND SUBMERSED APPLICATIONS

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

PART 3 EXECUTION

3.01 INSTALLATION

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

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

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

C. Provide joint harnesses for flexible couplings unless otherwise indicated on the Drawings with a written note.

END OF SECTION

SECTION 15211

DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CMAR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CMAR’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 CMAR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Testing, Training and Facility Start-Up.
      c. Section 02318 - Trenching.
      d. Section 09960 - High-Performance Coatings.
      e. Section 15052 - Common Work Results for General Process Piping.

1.02 REFERENCES

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

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   8. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   9. C606 - Standard for Grooved and Shouldered Joints.

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

D. ASTM International (ASTM):
   1. A 47 - Standard Specifications for Ferritic Malleable Iron Castings.
   2. A 183 - Standard Specifications for Carbon Steel Track Bolts and Nuts.
   3. A 536 - Standard Specifications for Ductile Iron Castings.
   4. C 283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
   5. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

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

F. NACE International (NACE):
   1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
   1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. Thrust restraint system design:
   1. Design restrained joint thrust restraint system.
   2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 15052 and the following additional criteria:
      a. Design pressure: Test pressure.
      b. Laying condition: Type 5 in accordance with AWWA C150.
      c. Soil designation: Silt 1 as defined by DIPRA.
      d. Unit friction resistance: Based upon polyethylene encasement of pipe.
      e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

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.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

C. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756.
   1. Manufacturer's test reports for polyurethane lining certifying successful performance of holiday detection tests.
      a. This documentation shall identify each piece by mark designation, and show the actual test results during the final inspection by the manufacturer prior to shipment.
      b. Acceptance criteria for glass lining shall be as specified under Field Quality Control.
   2. Manufacturer’s test results for glass lined pipe-certifying compliance with specified material requirements for glass lining.
   3. Include Coating Manufacturer’s Technical Representative’s reports.

D. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Lining manufacturers: For piping specified to receive glass or epoxy lining, use only a lining manufacturer having a minimum of 5 years' experience supplying this type of product to the wastewater and water industry.
   2. Welded on outlets: The pipe manufacturer shall have a minimum of 5 years' experience in the fabrication and testing of outlets of similar size and configuration similar to those used on the Project.

B. Pre-installation meeting:
   1. Arrange for Coating Manufacturer’s Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

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

C. 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.
   2. Type with screw-on flanges:
      a. In accordance with AWWA C115 with minimum special thickness Class 53 wall thickness as required for screw-on flanges.
      b. Special thickness class as indicated in the Piping Schedule as specified in Section 15052.
   3. Type with grooved couplings:
      a. Special thickness class as indicated in the Piping Schedule as specified in Section 15052.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
         1) Ductile iron.
         2) Long hub, threaded, and specially designed for ductile iron pipe.
         3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts: As specified in Section 15052.
      e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052.
   2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
      a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A 536, Grade 65-45-12, or malleable iron in accordance with ASTM A 47, Grade 32510.
      b. Bolts and nuts: In accordance with ASTM A 183, Grade 2.
      c. Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure. Material to be used for following services:
         1) For liquid service: NBR For air service: Fluoroelastomer.
         2) For hot water service: EPDM.
      d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
         1) Center-to-center dimensions: In accordance with AWWA C110.
         2) Wall thickness and other characteristics: In accordance with AWWA C606.
      e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
   3. Mechanical joints: In accordance with AWWA C111.
   4. Push-on rubber gasket joints: In accordance with AWWA C111.

5. Integrally restrained mechanical joints:
   a. Application:
      1) Where designation Mech Rest.
      2) MJ is specified in the Piping Schedule provided in Section 15052 supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.
      3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
      2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
   c. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
      1) American Cast Iron Pipe Company, MJ Coupled Joint.
      2) Pacific States Cast Iron Pipe Company, Lock Mechanical Joint.
      3) Griffin Pipe Products Co., Bolt-Lok.
      4) Griffin Pipe Products Co., Mech-Lok.
6. Integrally restrained push-on joints:
   a. Application:
      1) Where designation restrained push-on is specified in the Piping Schedule provided in Section 15052 supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
      2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
      2) Suitable for the following working pressures:
         a) For 4- through 24-inch pipe: 350 pounds per square inch gauge.
         b) For 30- through 54-inch pipe: 250 pounds per square inch gauge.
   c. Manufacturers: One of the following or equal:
      1) United States Pipe and Foundry Company, TR Flex.
      2) Pacific States Cast Iron Pipe Company, Thrust Lock.
      3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
      4) Griffin Pipe Products Co., Snap-Lok.
   d. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Fittings:
   1. Ductile iron in accordance with AWWA C110
   2. Joint type: Same as that of the associated piping as specified in Section 15052.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. Pipe linings:
   1. Cement-mortar lining:
      a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
      b. Minimum lining thickness: Standard in accordance with AWWA C104.
      c. Type of cement: Type 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. Coatings:
   1. Asphalt varnish: Factory applied.
   2. Primer:
      a. Factory applied for field coating.
      b. Compatible with materials as specified in Section 09960.

2.02 CERAMIC EPOXY LINING

A. The interior of all sludge pipe and fittings (BFP Sludge feed) as specified or indicated on the drawings shall be Protecto 401™ ceramic epoxy lining, 40 mils nominal dry film thickness or Permite Permox PCS-9043 Type II glass flake epoxy 50 mils nomial dry film thickeness.

B. The lining shall be applied by a certified firm with a successful history of applying above linings.

C. The pipe and fittings manufacturer shall provide a certificate attesting that the applicator met the requirements of this specification and the material used as specified.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 15052.
   2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318.

B. Polyethylene encasement:
   1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose polyethylene wrap in accordance with AWWA C105.
   2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
   3. At wall penetrations, extend encasement to the wall and neatly terminate.
   4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
   5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.

6. Repair tears and make joints with 2 layers of plastic tape.
7. All work shall be inspected prior to backfilling of pipe and associated items.

C. Joints:
1. Install types of joints as specified in the piping schedule provided in Section 15052.
2. Mechanical joints are not acceptable in above ground applications.
3. Field closure for restrained push-on pipe:
   a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
   a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 or indicated on the Drawings.
   b. Assemble grooved joints in accordance with manufacturer's published instructions.
   c. Support grooved-end pipe in accordance with manufacturer's published instructions.
      1) Install at least 1 support between consecutive couplings.

D. Tapping ductile iron pipe:
1. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
   a. Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	**Pressure Class**				
	150	**200**	**250**	**300**	**350**
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

   b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
   c. Two layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

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.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
Source Testing (Witnessed or Non-witnessed)	**Training Requirements**		**Installation Testing**		**Functional Testing**		**Process Operational Period**	
	Maintenance (hrs per session)	**Operation (hrs per session)**	**Trips**	**Days (each trip)**	**Trips**	**Days (each trip)**	**Trips**	**Days (each trip)**
Non-witnessed	Not required		Not required		Not required		Not required	

END OF SECTION

SECTION 15247

POLYVINYL CHLORIDE (PVC) GRAVITY SEWER PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gravity sewer pipe and fittings in accordance with ASTM D 3034 and ASTM F 679 standards.

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. ASTM International (ASTM):
   1. C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   2. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   4. D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   5. D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   6. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
   7. F 679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

1.03 ABBREVIATIONS

A. PVC: Polyvinyl chloride.

B. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Product data: Describe materials, pipe, fittings, and gaskets.

B. Manufacturer's Published Installation Instructions.

C. Certificates:
   1. Submit manufacturer's certificate attesting that pipe and fittings meet specified requirements in accordance with ASTM D 3034 and ASTM F 679, as applicable.
   2. Manufacturer's certification of date of manufacture of pipe for each lot delivered.

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 standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 PIPE

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. PVC compound: Cell classification 12454-C in accordance with ASTM D 1784.

C. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers not to exceed 10 parts by weight per 100 of PVC resin in the compound.

D. Pipe less than or equal to 15-inch diameter:
   1. In accordance with ASTM D 3034.
   2. Wall thickness SDR 26.
   3. Joints: Push-on in accordance with ASTM D 3212.
      a. Integral bell.
      b. Factory installed gaskets meeting the requirements in accordance with ASTM F 477.

2.02 FITTINGS

A. Same material as the pipe.

B. Minimum wall thickness: Same as the minimum wall thickness of the equivalent size pipe as specified in Table 1 of ASTM F 679.

C. Supplied by the pipe manufacturer.

D. Factory molded with joints and gaskets equal to those of the pipe.

E. Gasket:
   1. In accordance with ASTM F 477.
   2. Manhole adapter gasket: Stainless steel clamp with gasket or similar device to seal the penetration.

F. Flexible gaskets for precast bases with a flexible pipe connection:
   a. In accordance with ASTM C 923.
   b. Manufacturer: The following or approved equal:
      1) Press-Seal Gasket Corporation: PSX.
      2) A-Lok Premium.

G. Waterstop grouting rings:
   1. Manufacturer: The following or approved equal:
      a. NPC.
      b. Press-Seal Gasket Corporation.

2.03 SOURCE QUALITY CONTROL

A. Mark pipe and fittings in accordance with ASTM D 3034 and ASTM F 679 as appropriate.

B. Mark the production control code on pipe and fittings.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install piping in accordance with ASTM D 2321 and manufacturer's published installation instructions.
   2. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
   3. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.

B. Connections to manholes:
   1. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations using 1 of the following methods:
      a. Precast bases with a flexible pipe connection:
         1) Pipe connectors shall be cast into the base.
            a) Pipe openings shall contain flexible gaskets.
         2) Follow manufacturer’s recommendation for lubrication to prevent damage to the gasket during pipe insertion.
         3) When PSX gaskets are used, the take-up screws for the gasket clamps shall be positioned a minimum of 90 degrees apart.
         4) Install and grout in place per manufacturers instructions.

b. Cast in place or precast bases using grouting rings:
    1) Provide opening for connection large enough to allow subsequent grouting around the grouting ring.
    2) Grout around the pipe pentration manhole gasket and seal the opening.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15052 and Section 15956.

END OF SECTION

SECTION 15249

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Schedule type PVC 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 01330 - Submittal Procedures.
     b. Section 01756 - Testing, Training and Facility Start-Up.
     c. Section 15052 - Common Work Results for General Process Piping.
     d. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
  1. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  2. D 1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
  3. D 2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
  4. D 2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
  5. D 2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
  6. D 2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride)(PVC) Pipe and Fittings.
  7. F 645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

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

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

C. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756. Include as applicable:
   1. Date of manufacture of tubing for each lot delivered.
   2. Solvent cement manufacturer's report and certification.

D. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.04 QUALITY ASSURANCE

A. Pipe in potable water applications: Provide pipe bearing NSF 61 seal.

B. Mark pipe and fittings in accordance with ASTM D 1785.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle 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.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D 1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D 1784.
      b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052.
   2. Fittings: In accordance with ASTM D 2467.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 2-1/2 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 3 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft EPDM gasket.

3. Solvent cement:
    a. In accordance with ASTM D 2564.
    b. Manufacturers: The following or equal:
        1) IPS Corporation.
    c. Certified by the manufacturer for the service of the pipe.
    d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.
    e. Primer: As recommended by the solvent cement manufacturer.

2.02 SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D 1785.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in accordance with ASTM F 645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
    1. Do not thread pipe.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.

E. Solvent weld joints in accordance with ASTM D 2855.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15052 and Section 15956.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
    1. Provide Manufacturer’s Certificate of Source Testing.
    2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.

END OF SECTION

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SECTION 15740

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Heat pump units

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210-240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.
   3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration Systems.
   2. Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   3. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.

D. American National Standards Institute (ANSI):
   1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces) with Addenda.

E. Federal Specification (FS):
   1. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.

F. National Electrical Code (NEC).

G. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

H. National Fire Protection Association (NFPA):
   1. 54 - National Fuel Gas Code.
   2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

I. National Roofing Contractors Association (NRCA).

J. Underwriters' Laboratories, Inc. (UL).
   1. 900 - Standard for Air Filter Units.

1.03 DEFINITIONS

A. NEMA: Type 3R enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. System layout, mechanical, electrical power, and control diagrams.
   2. Nameplate information.
   3. Materials.
   4. Supports, vibration isolators, and seismic bracing calculations and details.
   5. Primary and ancillary equipment.
   6. Proposed cutting and patching, when required.
   7. Maximum recommended equipment vibration levels and field-testing method.
   8. Sound power level in each of 8 octave bands and overall Sones.
   9. Bearing life.
   10. Fan performance curves showing specified operating condition.
   11. Copy of factory test results.

C. Operation and maintenance data as specified in Section 01782 - Operation and Maintenance Data.

D. Warranties.

E. Provide required commissioning submittals as specified in Section 01756 - Commissioning.

1.05 QUALITY ASSURANCE

A. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels.

B. Qualification of manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce products of quality specified with a minimum 5 years satisfactory performance record.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece (or modular, if required), factory assembled, piped, internally wired, and factory tested.

B. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
   1. Provide temporary closures for equipment openings designed for airflow.

1.07 WARRANTY

A. Provide warranty as specified in the General Conditions.

B. Special warranties:
   1. Refrigerant compressors and closed or sealed refrigerant systems warranty duration: Provide 5-year warranty.
   2. Electric heaters (if supplied) warranty duration: Provide 5-year warranty.
   3. Evaporator and condensing coils warranty duration: Provide 5-year warranty.

1.08 MAINTENANCE

A. Extra materials: Provide 2 extra (3 total) sets of filters per unit installed.

B. Provide 1 set of sheaves and belts for change-out, if required, for final balance per unit installed.

C. After final balance, provide 1 extra set of belts for each unit installed.

D. Special tools: Deliver 1 set of special tools needed to assemble and disassemble the components of the unit requiring regular maintenance.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and 15050 - Common Work Results for Mechanical Equipment.

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

C. All supplied components of the unit shall be furnished and fully integrated by the unit system supplier, having unit responsibility:
   1. Furnish and install all piping, valves, dampers, sensors and wiring within the unit package.
   2. Provide a unit mounted control panel prewired on the unit to all dampers and sensors within the unit.

D. Motors:
   1. Totally enclosed.
   2. Voltage and number of phases as scheduled.
   3. Compressor motors:
      a. Cooled by refrigerant gas passing through windings.
      b. Provided with line break thermal and current overload protection.
   4. Fan and blower motors:
      a. Permanently lubricated ball bearings.
      b. Integral automatic reset thermal overload protection.
   5. Other requirements as specified.

E. Electrical:
   1. Provide a single conduit connection in the unit for both power and control wiring.

2.02 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 and Wind supports: Design supports to comply with the criteria specified in Section 01410 - Regulatory Requirements.
   6. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
   7. Roof curbs: Designed in accordance with NRCA Standards.
   8. Gas, water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code as specified in Section 01410 - Regulatory Requirements and in accordance with applicable codes.
   9. Fans supplied with heat pump units: Rated in accordance with AMCA 210.
   10. Unit heat pumps: Rated in accordance with AHRI Standards 210-240 or 340/360 and AHRI 270. Conform to the latest version of ASHRAE 15.
   11. Unit heat pumps with auxiliary heating options: Certified in accordance with ANSI Z21.47.
   12. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.
   13. Refrigerant: HCFC R-410A.
   14. Finishes: When not specified with fan type, coat ferrous metals as specified in Section 09960 - High-Performance Coatings.

B. Performance requirements:
   1. Performance requirements as specified and as scheduled on the Heat Pump Schedule indicated on the Drawings.
   2. Outdoor noise levels: Outdoor noise levels in the 8 octave band ranges, as measured in accordance with AHRI Standard 270 for unit heat pumps and split system heat pumps shall not exceed the following:

OCTAVE BANDS								
Unit Nominal Capacity (Tons)	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
0 to 5	64	70	71	74	74	71	67	67
6	79	85	78	74	71	73	66	59
7-1/2 to 10	64	70	73	79	82	78	74	67
12 and larger	84	88	84	83	84	78	72	68

   3. Units shall be capable of starting and running from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI Standard 210-240 or 340/360.

4. Capable of starting and providing heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
5. Minimum cooling and heating capacities, energy efficiency ratios (EER), and coefficient of performance (COP), as rated in accordance with AHRI 210-240 or 340/360 and 270, unless scheduled otherwise:

				Heating High Temperature(1)		**Heating Low Temperature(2)**	
Nominal Capacity (Tons)	**Standard cfm**	**Cooling Capacity (Btuh)**	**EER(3)**	**Capacity (Btuh)**	**COP**	**Capacity (Btuh)**	**COP**
3	1,200	36,400	11.0	35,200	3.0	18,400	2.0
4	1,750	47,000	11.0	47,000	3.0	26,400	2.0
5	2,000	59,000	11.0	59,000	3.0	26,400	2.1
6	2,400	72,800	11.0	70,400	3.0	36.800	2.0
7-1/2	3,000	87,000	11.0	89,000	3.0	49,000	2.0
10	4,000	113,000	11.0	116,000	3.0	65,000	2.0

Notes:

(1) High temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 47 degrees Fahrenheit dB, 43 degrees Fahrenheit wet bulb outdoor entering air temperature.

(2) Low temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 17 degrees Fahrenheit dB, 15 degrees Fahrenheit wet bulb outdoor entering air temperature.

(3) EER value:
   a. Deduct 0.2 from the required EER’s for units with a heating section other than electric resistance heat.
   b. EER value based on CCR Title 24 requirements.

1. Units with heating capabilities: Meet or exceed the following efficiencies:
   a. Annual fuel utilization efficiency: 80 percent.
   b. Steady state efficiency: 80 percent.
2. 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.
3. Filter:
   a. Media: UL 900 listed, Class I or Class II, approved by local authorities.
   b. Efficiency: 45 to 50 percent dust spot efficiency when rated per ASHRAE Test Standard 52.2.
   c. Face velocity: Per manufacturer recommendation.

2.03 MINI-SPLIT SYSTEM HEAT PUMPS

A. Manufacturers: One of the following or equal:
   1. Mitsubishi, Series PUZ; when indoor air handling unit scheduled, Series PKA (wall mounted).
   2. Samsung, similar series.
   3. Daikin, similar series.
   4. Trane, similar series.

B. Compressors:
   1. Fully hermetically-sealed, high-efficiency, reciprocating or rotary or scroll-type, with rubber grommet vibration isolation.

C. Fans:
   1. Indoor air fan:
      a. Direct driven with capacitor start motor; double inlet, forward curve sirocco fan, steel with corrosion resistant finish, statically and dynamically balanced.
      b. Bearings: permanently sealed ball bearing type and permanently lubricated.
   2. Outdoor condenser fan:
      a. Propeller type, direct drive, aluminum blades, dynamically balanced.
      b. Bearings: Permanently sealed ball bearing type and permanently lubricated.

D. Coils:
   1. Evaporator and condenser coils: seamless copper tubes with mechanically bonded aluminum plate fins.
   2. Provide corrosion resistant finish, suitable for marine environment.

E. Refrigerant components: Refrigerant circuit including:
   1. Accumulator and filter/drier.
   2. Expansion device.
   3. Reversing valve.
   4. Flow control valves.
   5. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.

F. Controls and equipment safety features:
   1. Provide system controls for a complete functioning system:
      a. High and low evaporator fan speed control for cooling and heating modes.
      b. Fan only operation.
      c. Ventilation control; closed.
      d. Space temperature condition setting.
      e. Vapor bellows thermostat to cycle unit to maintain space condition.
   2. Equipment safety features:
      a. Thermostatic base pan drain to prevent freeze up of the fan in collected condensate.
   3. Provide with a low ambient cooling option.

G. Unit casing:
   1. Slide-out design unit casing manufactured of high strength molded plastic with smooth finish and outdoor casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, polyester powder coating for corrosion protection.
   2. Weatherproof design, reinforced and braced for maximum rigidity.
   3. Provided with:
      a. Filter rack for filters accessible through the front or top of the unit.
      b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
      c. Horizontal drain connection.
      d. Provide mini condensate pump suitable to be powered from indoor/outdoor unit.
      e. Knockouts for power connections.
      f. Provide wall sleeve of galvanized steel coated similar to unit casing.

2.04 ACCESSORIES

A. Sensors: Provided by manufacture.

B. Provide hail guard to protect against damage from hail and other flying debris.

C. Provide coil guard grill to protect condenser coil from penetration by large objects.

D. Provide condensate drain per mechanical code as specified in Section 01410 - Regulatory Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners, as specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Prior to installation, protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
   1. Provide temporary closures for equipment openings designed for airflow.

C. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

D. Examine and verify details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.
   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.

3.02 INSTALLATION

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Before installation, remove dust and debris from equipment and ducts.

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.
   2. Provide anchoring and support per section 01410 - Regulatory Requirements.

C. Adjust alignment of ducts and equipment 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. Upon completion of installation, clean duct, and debris from ductwork, and equipment.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Source Testing.
      b. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trips, 1 day minimum each.
   3. Training:
      a. Maintenance: 2 hours per session, 2 sessions.
      b. Operation: 1 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Source testing:
   1. Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Equipment:
      a. Test witnessing: Not witnessed.
      b. Conduct Level 1 General Equipment Performance Test.
      c. Conduct Level 1 Vibration Test.
      d. Conduct Level 1 Noise Test.
      e. Factory test in cooling and heating modes including economizer operation. Evacuate coils and refrigerant system for 30 minutes prior to final charging of unit before shipment.
   3. Electrical Instrumentation and Controls:
      a. Test witnessing: Not witnessed.

D. Functional testing:
   1. Equipment:
      a. Test witnessing: Witnessed.
      b. Conduct Level 1 General Equipment Performance Test.
      c. Conduct Level 1 Vibration Test.
      d. Conduct Level 1 Noise Test.
      e. Test equipment and installation to verify tightness, operation, and unit heat pump vibration is within manufacturer's submitted maximum.
      f. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.
      g. Test for outdoor sound power at levels.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.

3.04 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

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SECTION 15954

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Heating, ventilation, and air conditioning systems testing, adjusting, and balancing.

1.02 REFERENCES

A. Associated Air Balance Council (AABC):
   1. National Standards for Field Measurements and Instrumentation, Total System Balance, Air Distribution-Hydronic Systems.

B. National Environmental Balancing Bureau (NEBB):
   1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. Heating, Ventilating, and Air Conditioning Systems - Testing, Adjusting, and Balancing.

D. Testing, Adjusting, and Balancing Bureau (TABB):
   1. International Standards for Environmental Systems Balance.

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 AABC, NEBB, or the TABB to perform air balancing, testing, and adjustment of building and process air conditioning, heating, and ventilating air systems.

B. The Work includes: Balancing new air systems installed as part of this contract and existing air systems affected by the installation of new equipment.

C. Perform testing of heating, ventilating, and air conditioning equipment, balancing of distribution systems, and adjusting of air terminal units and ductwork accessories to ensure compliance with Specifications and Drawings. Perform tests for following:
   1. Split System Heat Pumps

D. Test each mode of operation of thermostats, electronic controllers, and pneumatic, electric or electronic heating, ventilating, and air conditioning instruments to ensure operation as specified.

E. Test and adjust room distribution patterns at air outlets.

F. Provide instruments required for testing, adjusting, and balancing operations; retain possession of instruments; remove instruments from site at completion of services.

G. Make instruments available to the Engineer to facilitate spot checks during testing.

H. Provide test holes for pressure and pitot flow measurements; provide plugs for all test holes after testing.

1.04 QUALITY ASSURANCE

A. Test, balance, and adjust environmental systems in accordance with either:
   1. AABC: National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronic System.
   2. NEBB: Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
   3. TABB: International Standards for Environmental Systems Balance.

B. Perform services under direction of AABC, NEBB, or TABB 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 airflow, 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 airflow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

D. Proposed schedule for testing and balancing.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.06 SITE CONDITIONS

A. Prior to start of testing, adjusting, and balancing, verify that:
1. Systems installation is complete and in full operation.
2. Outside conditions are within reasonable range relative to design conditions.
3. Lighting fixtures are energized.
4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Perform Functional Tests as specified in Section 01756 - Commissioning.

B. 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 airflows meet acceptance criteria.
   1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.

D. Initial testing, adjusting, and balancing: Perform first test on each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, 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 cubic feet per minute 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 AABC, NEBB, or TABB 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, NEBB, or TABB procedures.
   1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
   2. Complete appropriate AABC, NEBB, or TABB 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

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SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Test requirements for piping systems.

B. Related Sections:
   1. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

A. Uniform Plumbing Code (UPC).

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

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

D. Uniform Mechanical Code (UMC).

1.03 TESTING REQUIREMENTS

A. General Requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052; are specified in the specifications covering the various types of piping; and are specified herein.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the Uniform Plumbing Code, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the pressure at the highest point of the piping section under test. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. 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.

D. 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.

E. Test Completion: Drain and leave piping clean after successful testing.

F. Test Water Disposal: Dispose of testing water at site storm water retention pond in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.04 SUBMITTALS

A. Schedule and Notification of Tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of Readiness to Test: Immediately before testing, notify ENGINEER in writing of readiness, not just intention, to test piping. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and Grade:
1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection Test:
1. Pull a mandrel through the clean piping section under test.
2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
3. Use a 9 rod mandrel with a contact length of not less than the nominal diameter of the pipe within one percent plus or minus.
4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test 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. For plastic piping test for deflection.

c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours.
   a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
   b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
   c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of four hours while accurately measuring the volume of water added to maintain the test pressure.
      1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
         a) For Concrete Piping with Rubber Gasket Joints: 80 gallons per day per inch of diameter per mile of piping under test.
            (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
         b) For Vitrified Clay and Other Piping: 500 gallons per day per inch of diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping schedule.

B. General:
1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do not include valves, equipment or piping specialties in test sections if test pressure exceeds the valve, equipment or piping specialty safe test pressure allowed by the item's manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When Test Results Indicate Failure of Selected Sections, Limit Tests to Piping:
   a. Between valves.
   b. Between a valve and the end of the piping.
   c. Less than 500 feet long.

7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing Procedures:
   1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
   3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
      c. When leakage is allowed, calculate the allowable leakage by the following formula:

         $L = S \times D \times P^{1/2} \times 133{,}200^{-1}$

         wherein the terms shall mean:

         L = Allowable leakage in gallons per hour.

         S = Length of the test section in feet.

         D = Nominal diameter of the piping in inches.

         P = Average observed test pressure in pounds per square inches, gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

         x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible Leaks Test:
   1. Subject piping under test to the specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with potable water while venting air.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional Joint Test:
   1. When joint testing is allowed by note in the piping schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.
   2. Joint testing may be performed with water or air.
   3. Joint test piping after completion of backfill and compaction to the top of the trench.
   4. Joint Testing with Water:
      a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
      b. Maintain test pressure for one minute.
      c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
      d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
      e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.

5. Joint Testing with Air:
   a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
   b. Maintain test pressure for 2 minutes.
   c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

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

B. Related Sections:
   1. Section 01756 - Testing, Training, and Facility Start-up.
   2. Section 15956 - Piping Systems Testing.
   3. Section 16050 - Electrical General Provisions.
   4. Division 17 - Instrumentation and Control System.

1.02 REFERENCES

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

B. American National Standards Institute/Hydraulic Institute (ANSI/HI):
   1. ANSI/HI 1.1-1.5 Standard for Centrifugal Pumps for Nomenclature, Definitions, Application, and Operation.
   2. ANSI/HI 1.6 Standard for Centrifugal Pump Tests.
   3. ANSI/HI 2.1-2.5 Standard for Vertical Pumps for Nomenclature, Definitions, Application, and Operation.
   4. ANSI/HI 2.6 Standard for Vertical Pump Tests.
   5. ANSI/HI 3.1-3.5 Standard for Rotary Pumps for Nomenclature, Definitions, Application, and Operation.
   6. ANSI/HI 3.6 Standard for Rotary Pump Tests.
   7. ANSI/HI 4.1-4.6 Standard for Sealless Rotary Pumps for Nomenclature, Definitions, Application, Operation, and Test.
   8. ANSI/HI 5.1-5.6 Standard for Sealless Centrifugal Pumps for Nomenclature, Definitions, Application, Operation, and Test.
   9. ANSI/HI 6.1-6.5 Standard for Reciprocating Power Pumps for Nomenclature, Definitions, Application, and Operation.
   10. ANSI/HI 6.6 Standard for Reciprocating Pump Tests.
   11. ANSI/HI 7.1-7.5 Standard for Controlled Volume Pumps for Nomenclature, Definitions, Application, and Operation.
   12. ANSI/HI 8.1-8.5 Standard for Direct Acting for Steam Pumps for Nomenclature, Definitions, Application, and Operation.
   13. ANSI/HI 9.1-9.5 Standard for Pumps - General Guidelines for Types, Definitions, Application, and Sound Measurement.

1.03 SUBMITTALS

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

B. Test instrumentation calibration data.

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

D. Test Plan specified in this Section.

E. Test result reports.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 QUALITY CONTROL TESTING AND REPORTING

A. Scheduling and Notification:
1. Witnessed Source Quality Control Tests: Schedule test date and notify ENGINEER at least 30 days prior to start of test.
2. Field Quality Control Tests: Schedule test date and notify ENGINEER at least 7 days prior to start of test.

B. Testing Levels:
1. Test equipment based on test levels specified in the equipment Section of the Specifications.
2. Requirements for Test Levels 1 to 4 are defined below.
3. Test levels apply for both Source (Factory) Quality Control Tests and Field Quality Control Tests as specified in the individual equipment Sections of the Specifications.
4. If testing is not specified in the equipment Section, provide Level 1 testing.
5. Requirements of Section 01756 apply to Test Levels.

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

D. Instrumentation: Provide necessary test instrumentation, which has been calibrated within one year from date of test to recognized test standards traceable to the National Institute of Standards and Technology, Washington, D.C. or approved source. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for Field Quality Control Tests.

E. Temporary Facilities and Labor: Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing. With OWNER's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

F. Test Fluids:
1. Factory Tests: Use water or air as appropriate at ambient conditions unless specified otherwise in the equipment Section.
2. Field Tests: Use specified process fluid at available conditions.

G. Pressure Testing: Hydrostatically pressure test pressure containing parts in the factory at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher. Submit pressure test reports before shipping.

H. Test Measurement and Result Accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

I. Field Testing:
   1. Submit test plan as specified in Section 01756 and this Section. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on OWNER's existing equipment and other information relevant to the test. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.
   2. Perform general start-up and testing procedures as specified in Section 01756.
   3. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.

J. Reports: Submit reports for Source and Field testing. Submit Source Quality Control Test result reports before shipping equipment to the field. Report features:
   1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
   2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
   3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
   4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
   5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

3.02 EQUIPMENT TESTING, GENERAL

A. Tests for Pumps, All Levels of Testing:
   1. Test in accordance with applicable Hydraulic Institute Standards in addition to the requirements in this and other Sections.
   2. Test Tolerances: In accordance with appropriate Hydraulic Institute Standards, except the following modified tolerances apply:
      a. From 0 to plus 5 percent of head at the specified flows.
      b. 0 to plus 5 percent of flow at the rated design point head.
      c. No negative tolerance for the efficiency at the specified flows.

d. No positive tolerance for vibration limits. Vibration limits and test methods in 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 Division 16. Test other drivers as specified in the driver equipment Section.

3.03 REQUIREMENTS FOR VIBRATION TESTING

A. Definitions:
1. Peak to Peak Displacement: The root mean squared average of the peak to peak displacement multiplied by the square root of 2.
2. Peak Velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
3. Peak Acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
4. High Frequency Enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectra of acceleration versus frequency. Manufacturers: One of the following or equal:
    a. Rockwell Automation, Entek Group, "Spike Energy" analysis.
    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 6400 lines, storage for up to one hundred 3200 line frequency spectra, RS232C data output port, circuitry for integration of acceleration data to velocity or double integration to displacement. Manufacturers: One of the following or equal:
    a. 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 1600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3200 lines for motors with a nominal speed of 3600 rpm; 3200 lines minimum for High Frequency Enveloping; 1600 lines minimum for low speed equipment.
    c. Sample Averages: 4 minimum
    d. Maximum Frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
    e. Amplitude Range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.

f. Fast Fourier Transform Windowing: Hanning Window.
g. High Pass Filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

3. Accelerometers:
   a. For Low Speed Equipment: Low frequency, shear mode accelerometer, 500 millivolts per g sensitivity, 10 g range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount. Manufacturers: One of the following or equal:
      1) Wilcoxon Research, Model 797L.
      2) PCB, Model 393C.
   b. For High Speed Equipment: General purpose accelerometer, 100 millivolts per g sensitivity, 50 g range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder. Manufacturers: One of the following or equal:
      1) Wilcoxon Research, Model 793.
      2) 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 16405 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 16405. Use actual driver for field tests.
c. Test for flow and head at two additional conditions; one at 25 percent below the rated flow and one at 10 percent above the rated flow.
d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

3. Level 2 Vibration Test:
   a. Test Requirement: Measure filtered vibration spectra for peak velocity, peak to peak displacement versus frequency and measure vibration phase in three perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; one plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
   b. Equipment Operating Condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
   c. Natural Frequency Test of Field Installed Equipment:
      1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears and supports.
      2) Perform test at each bearing housing and at each support pedestal and for pumps on the suction and discharge piping.
      3) Perform with equipment and attached piping full of intended service or process fluid.
4. Level 2 Noise Test:
   a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at three feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Quality Control Tests:
   1. Level 3 General Equipment Performance Tests:
      a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
      b. Operate at rated design load conditions for one half the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
      c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
      d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
      e. Bearing Temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 3 Pump Performance Test:
   a. Test four hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16405. Use actual driver for field tests.
   c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
   d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment specification) and record observations on noise levels.
3. Level 3 Vibration Test:
   a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
   b. Perform High Frequency Enveloping Analysis for gears and bearings.
      1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
      2) Report results in units of acceleration versus frequency in cycles per minute.
   c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
   d. Plot vibration spectra on three different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at four locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Quality Control Tests:
1. Level 4 General Equipment Performance Test:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions for one half the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
   c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.

d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
e. Bearing Temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 4 Pump Performance Test:
   a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field testing, test with furnished motor at full speed.
   b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
   c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment specification) and record observations on noise levels.
   d. Bearing Temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
   e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment Section in accordance with the appropriate ANSI/HI standard and as follows:
      1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
      2) Perform efficiency testing with test fluids at maximum rated speed.
      3) Perform priming time testing with test fluids at maximum rated speed.
3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

3.05 SOURCE QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in individual equipment sections. Prepare and submit test reports as specified.

B. Inspection and Balancing:
   1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
   2. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

C. Critical Speed of Rotating Equipment: Satisfy the following:
   1. First critical speed of the constant, variable, and 2-speed driven equipment is to be at least 25 percent above the maximum operating speed or 25 percent below the minimum operating speed.
   2. Second critical speed of any 2-speed or the variable speed equipment is to be at least 25 percent above or below the maximum operating speed or 25 percent below the minimum operating speed.

3.06 FIELD QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in individual equipment Sections. Prepare and submit test reports as specified. Comply with latest version of applicable standards.

B. For variable speed equipment, conduct test to establish performance over the entire speed range and at the average operating condition. Establish performance curves for:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

3.07 VIBRATION ACCEPTANCE CRITERIA

A. Testing of Rotating Mechanical Equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.

B. Vibration Displacement Limits: Unless otherwise specified, equipment is not to exhibit unfiltered readings in excess of following:

Operating Speed (revolutions per minute)	Centrifugal Blowers	Unfiltered (Overall) Peak-to-Peak Amplitude (mils)		
		Other Rotating Equipment	**Non-Clog Mixed Flow Pumps**	**Clean Fluid Pumps**
0 - 300	N/A	5.0	6.0	6.0
301 - 600	N/A	4.0	5.0	5.0
601 - 900	N/A	3.0	4.0	3.0
901 - 1,200	N/A	2.0	5.7	2.0
1,201 - 1,500	N/A	1.8	3.0	1.8
1,501 - 1,900	N/A	1.5	2.5	1.5
1,801 - 2,400	N/A	1.0	2.0	1.0
2,401 - 3,000	N/A	0.8	1.5	0.8
3,001 - 3,600	1.25	0.7	1.3	0.7
Above 3,600	1.0	0.6	1.2	0.6
Note: For all equipment, axial shaft displacements not to exceed 50 percent of the maximum radial shaft displacements relative to the casing.				

C. Vibration Velocity Limits: Unless otherwise specified, equipment is not to exceed the following peak velocity limits:

Item	Unfiltered Overall Limit (inches per second)	Any Filtered Peak Limit (inches per second)
Non-Clog or Mixed Flow Pumps	0.44	0.25
Clean Fluid Pumps	0.25	0.20
Motors and Steady Bearings	0.25	0.20
Gear Reducers, Radial	Not to exceed AGMA 6000-A88 limits	
Other Reducers, Axial	0.10	0.10
Centrifugal Blowers	0.15	0.10
Other Equipment, Radial	0.16	0.10
Other Equipment, Axial	0.10	0.10

D. Equipment Operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

E. Additional Criteria:
1. No narrow band spectral vibration amplitude components, whether subrotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.
2. The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
3. For Motors, the Following Shall be Cause for Rejection:
   a. Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.
   b. Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
   c. Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around two times the rotor bar pass frequency.
   d. Phasing problems evidenced by one third line frequency side band spectral peaks around the 2 times electrical line frequency peak.

4. The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

3.08 NOISE REQUIREMENTS AND CONTROL

A. Make measurements in relation to reference pressure of 0.0002 microbar.

B. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

C. Set sound level meter to slow response.

D. Unless otherwise specified, maximum free field noise level not to exceed 88 dBA measured as sound pressure level at 5 feet from the equipment.

3.09 FUNCTIONAL AND OPERATIONAL TESTING OF EQUIPMENT

A. Functional testing as specified in Section 01756 and this Section.

B. General Check-out: Prior to operating equipment, inspect, test, and check supporting systems, including but not limited to power systems, control systems, piping systems, lubrication systems, and safety systems.
   1. Test and calibrate instrumentation and electrical devices as specified in Division 16 and 17.
   2. Test and prepare piping as specified in Section 15956.
   3. As a minimum for control systems associated with the equipment, perform the following:
      a. Individual Loop Tests: Test from field device to intermediate terminations to controller and back to controlled element.
      b. End to End Test: Simulate input at field device and observe control system response at the final field control element.
   4. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

C. Operation of Related Existing Equipment: OWNER will operate related existing equipment or facilities necessary to accomplish the testing.

D. Acceptable Tests: Demonstrate the equipment performance meets the requirements of this Section and the equipment Section; when the equipment fails to meet the specified requirements, perform additional more detailed testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.

E. Operational Testing: As specified in Section 01756.

END OF SECTION

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to all sections in Division 16, ELECTRICAL. Work specified herein shall be performed as if specified in the individual sections.

1.02 ELECTRICAL SUBCONTRACTOR QUALIFICATIONS

A. The electrical subcontractor shall meet or exceed the criteria described below:
   1. The electrical subcontractor shall be licensed in the State of Florida.
   2. The electrical subcontractor shall have successfully completed electrical construction on three water or wastewater treatment plant related projects within the past six years.
   3. The electrical subcontractor shall have, in their employ, the following full-time employees that will be assigned to perform the electrical work of this contract:
      a. A minimum of (1) Licensed Master Electrician who is overall responsible for the supervision of personnel performing the construction, installation startup and testing of all electrical related facilities and systems.
      b. A minimum of (1) Licensed Journeyman Electrician responsible for the daily construction activities and guidance of the electrical contractor's on-site employees. The Licensed Journeyman's primary assignment will be the construction of the electrical facilities of this project until project completion. The Licensed Journeyman shall be certified in Volusia County or shall meet the reciprocity standards of Florida State Statue 489 Part II.
   4. The electrical subcontractor shall not be involved in any current or pending litigation which may have a material negative impact on the ability to complete the project. The electrical subcontractor shall provide a statement advising all current or pending litigations.

1.03 DESIGN REQUIREMENTS

A. All electronic boards as part of electrical equipment shall meet the atmospheric conditions of the space the equipment is installed in. All electronic boards, which are not installed in a conditioned environment, shall be fungus-resistant.

B. All electrical equipment shall be rated for the conditions the equipment is installed in.

1.04 STANDARDS, CODES, PERMITS, AND REGULATIONS

A. Perform all work; furnish and install all materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
   1. Local Laws and Ordinances.

2. State and Federal Laws.
3. National Electrical Code (NEC).
4. State Fire Marshal.
5. Underwriters' Laboratories (UL).
6. National Electrical Safety Code (NESC).
7. American National Standards Institute (ANSI).
8. National Electrical Manufacturer's Association (NEMA).
9. National Electrical Contractor'S Association (NECA) Standard of Installation.
10. Institute of Electrical and Electronics Engineers (IEEE).
11. Insulated Cable Engineers Association (ICEA).
12. Occupational Safety and Health Act (OSHA).
13. National Electrical Testing Association (NETA).
14. American Society for Testing and Materials (ASTM).
15. Florida Building Code, including Local County/City amendments.

B. Conflicts, if any, which may exist between the above items, will be resolved at the discretion of the Engineer.

C. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

D. Obtain all permits and pay all fees required by any governmental agency having jurisdiction over the work. Arrange all inspections required by these agencies. On completion of the work, furnish satisfactory evidence to the Engineer that the work is acceptable to the regulatory authorities having jurisdiction.

1.05 ELECTRICAL COORDINATION

A. Work Provided Under this Contract:
1. Perform electrical demolition works as shown on drawings and as per specifications. Provide temporary power as shown on drawings and as per section 1.05.B of this specification.
2. Provide and install the complete electrical power distribution system shown on the drawings including equipment space and supporting raceway for future equipment.
3. Existing MCC-3 at the existing Dewatering Building shall be removed and provide and install new MCC-3 as shown on drawings and as per specifications. Make all necessary modifications, terminations, connections, etc. for a complete and working switchboard system in place.
4. Provide and install all electrical equipment indicated on the drawings and described in the specifications including motor control centers, variable frequency drives, disconnects, local starters, wire, raceway etc. complete in place.
5. Provide and install new lighting system as indicated on the drawings, complete in place.
6. Provide and install all conduit and wire required for power, instrumentation, and control systems complete in place.
7. Provide and install all electrical required to support HVAC systems as shown on the drawings complete in place.

8. Provide all miscellaneous electrical including disconnect switches, terminations, fittings, junction boxes, terminal junction boxes, mounting supports, etc. not specified but obviously necessary for complete working systems in place.
9. Provide coordination study as per specification 16015.
10. Provide rubber mats in front of new MCC's as per this specification.

B. Temporary Power:
1. Provide temporary power for all office trailers and for all construction areas. Coordinate with local power and telephone utility for temporary construction power and telephone service during construction.
2. Provide all material and labor for the installation and maintenance of temporary construction power requirements for the project.
3. Provide temporary power for 2nd floor belt filter press units to keep them in operation during construction of 1st floor belt filter press units and conveyors and demolition of exposed conduits mounted on the ceiling of 1st floor. All costs associated with the temporary power, temporary cables, labor, supports, etc. for the period of temporary power usage shall be included as part of Contractor's Bid price.

C. Construction Constraints:
1. New MCC-3 shall be in place and ready for connection before demolition of existing MCC-3 begins, unless otherwise noted.
2. Coordinate with Owner on the timing of demolition works. The existing belt filter press (BFP) units on the 2nd floor will need to be in operation as long as possible and to minimize the rental time of mobile sludge dewatering unit. New belt filter press (BFP) units and conveyors at the 1st floor shall be ready for operations before demolition of belt filter press units on the 2nd floor, unless otherwise noted.

1.06 SUBMITTALS

A. Quality Control Submittals:
1. Factory test certification and reports for all major electrical equipment.
2. As part of the electrical submittal, the contractor shall provide a minimum of 1/2"=1'-0" scaled layout of the electrical equipment in the existing electrical room, new electrical room, or major electrical equipment in a mechanical room showing sizes of all equipment and their spatial relationship. Non-electrical equipment shall be approved before finalizing the electrical layout in mechanical rooms. Adjust electrical room layout based on the actual equipment dimension from the approved shop drawings.
3. Submit exposed conduit layout plan of dewatering building – 1ST floor for approval.

B. The following information shall be provided for electrical equipment furnished under specifications 16050 Basic Electrical Materials and Methods; 16480 MCC, 16485 Variable Frequency Drives:
1. A copy of each specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (√) shall denote full compliance with a paragraph as a whole. If deviations from

the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation.

2. Electrical equipment submittals shall be made by specification section. Submit one package per specification section and do not group multiple specification sections under one submittal package.
3. Provide complete underground and exposed conduit layout and equipment layouts: a scaled plan layout of the new and existing electrical room(s) showing spatial relationships of all equipment as well as the overall size of the room as stated in section 1.06.A.2.
4. Provide a conduit plan for major power, instrumentation and control conduits, both interior and exterior, showing routing, size and stub up locations for buried or in slab conduits.

1.07 ENVIRONMENTAL CONDITIONS

A. All chemical rooms and areas shall be designated as corrosive.

B. All indoor chemical and process equipment areas shall be considered wet locations.

C. Electrical equipment in rooms designated as Classified by NFPA 70 (national electrical code) as Division 1 or Division 2 shall meet all requirements set forth for that classification as described in NEC article 500.

1.08 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. The Electrical Drawings were developed from past record drawings and information supplied by the Owner. Verify all scaled dimensions prior to submitting bids.

B. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to visit the site and determine conditions at the site before submitting their bid.

C. Carry out any work involving the shutdown of the existing services to any piece of equipment now functioning in existing areas at such time as to provide the least amount of inconvenience to the Owner. Do such work when directed by the Engineer.

D. After award of Contract, locate all existing underground utilities at each area of construction activity. Protect all existing underground utilities during construction. Pay for all required repairs without increase in Contract cost, should damage to underground utilities occur during construction.

1.09 RESPONSIBILITY

A. The Contractor shall be responsible for:
1. Complete systems in accordance with the intent of these Contract Documents.
2. Coordinating the details of facility equipment and construction for all Specification Divisions, which affect the work, covered under Division 16, ELECTRICAL.

3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.

1.10 INTENT OF DRAWINGS

A. Electrical plan Drawings show only general location of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for the proper routing of raceway, subject to the approval of the Engineer.

B. All electrical equipment sizes and characteristics have been based on manufacturer GE, Square D and Eaton (Cutler-Hammer) except otherwise noted on drawings or in other specifications. If the Contractor chooses to and is allowed to substitute, the Contractor shall be responsible for fitting all the equipment in the available space as shown on the Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide materials and equipment listed by UL wherever standards have been established by that agency. All panels shall have appropriate UL label.

B. Equipment Finish:
1. Provide manufacturers' standard finish and color, except where specific color is indicated.
2. If manufacturer has no standard color, provide equipment with ANSI No. 61, light gray color.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

B. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

3.02 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panel boards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.03 CHECKOUT AND STARTUP

A. Equipment Line Current Tests:
   1. Check line current in each phase for each piece of equipment.
   2. If any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

B. Startup:
   1. Demonstrate satisfactory operation of all 480-volt electrical equipment. Participate with other trades in all startup activities.
   2. Assist the Instrumentation and Control (I&C) Contractor in verifying signal integrity of all control and instrumentation signals.

3.04 RUBBER MATS

A. A three foot wide rubber mat shall be furnished and installed on the floor and in front of each MCC, existing VFD assembly, and PLC control panel. The mat shall be long enough to cover the full length of each line-up. The mat shall be 1/4 inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The mat shall be guaranteed extra quality, free from cracks, blow holes, or other defects detrimental to their mechanical or electrical strength. The mat shall meet OSHA requirements and the requirements of ANSI/ASTM D-178 J6-7 for Type 2, Class 2 insulating matting.

END OF SECTION

SECTION 16015

ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The requirements of this specification shall apply to the new electrical distribution system or modification of the existing electrical distribution system at City of Daytona Beach – Westside Regional Water Reclamation Facility added or modified under this contract (Dewatering Building) as shown on one line diagrams and as describes in this specification. The end result shall be a fully protected, and properly coordinated, system with proper arc flash safety labels and personal protective equipment recommendations.

B. Contractor shall furnish short-circuit and protective device coordination studies as described herein. The coordination study shall begin with the new MCC-3 include all of the new electrical protective devices down to, and including, the main breaker and feeder circuit in each 208 Volt panelboard. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with emergency and standby generators associated paralleling equipment and distribution switchgear, if applicable. Contractor shall obtain the previous coordination study (on-going CMAR project) from the Owner and use the data at the two existing MCC-A and MCC-B to perform the coordination and arc flash study associated with this project. Coordinate with Owner to obtain a copy of the existing study data after the project is awarded.

C. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex.

D. The new arc flash label shall match the style and format with the existing labels where possible. If existing arc flash labels are generic type, provide coustom arc flash labels as required by NFPA 70E.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
      b. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
      c. IEEE 242: Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
      d. IEEE 399: Recommended Practice for Industrial and Commercial Power System Analysis.
      e. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
      f. IEEE 1584-2002: Guide for Performing Arc Flash Hazard Calculations.

2. American National Standards Institute (ANSI):
    a. C57.12.00, Standard General Requirements for Liquid-immersed Distribution, Power, and Regulating Transformers.
    b. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
    c. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
    d. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
    e. eANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents
3. National Fire Protection Association:
    a. NFPA 70E: National Electrical Safety Code Chapter 1.
    b. NFPA 70: National Electrical Code.
4. Occupational Safety & Health Administration (OSHA):
    a. 29-CFR, Part 1910, sub part S.

1.03 SUBMITTALS

A. Shop drawings: the results of the short-circuit; protective device coordination and arc flash hazard analysis studies shall be summarized in a preliminary and final summary report. Submit five (5) three-ring binder bound copies of the complete preliminary and final study reports. The preliminary short circuit and device coordination study report shall be submitted within 30 days of notice to proceed and shall be a basis for approval of all other electrical equipment in the power distribution system. The contractor is expected to review the results of the preliminary short circuit and device coordination study report against all other applicable shop drawings, including industrial control panels, prior to shop drawing submittal to coordinate appropriate fault duty ratings of all electrical equipment. The final short circuit and device coordination study report shall incorporate all comments from shop drawing submittals and include the arc-flash hazard analysis. The contractor shall ensure proper arc-flash warning labels are applied to all appropriate electrical equipment installed under this contract when the final study has been approved.

1.04 QUALITY ASSURANCE

A. Short circuit, protective device coordination, and arc flash studies shall be prepared by the manufacturer furnishing the electrical power distribution equipment or a professional electrical engineer registered in the State of Florida, hired by the manufacturer, in accordance with IEEE 242 and IEEE 399.

B. Manufacturer shall have unit responsibility for the equipment and protective device coordination.

1.05 SEQUENCING AND SCHEDULING

A. An initial, complete short circuit and arc flash study must be submitted and reviewed before Engineer will approve Shop Drawings for switchgear, unit sub stations, breakers, MCC'S, switchboard, VFD'S, manufactured industrial control panels and circuit breaker panelboard equipment. Failure to do so will delay the approval of major equipment submittals.

B. The short circuit, protective device coordination and arc flash studies shall be updated prior to Project Substantial Completion. Utilize characteristics of as-installed equipment actual wire run lengths and materials.

PART 2 PRODUCTS

2.01 GENERAL

A. Contractor shall furnish all field data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing. As-built drawings for existing electrical equipment are available if requested to the Owner.

B. Source combination may include present and future utility supplies, motors, and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.

D. Equipment and component titles used in the studies shall be identical to the equipment and component titles shown on the Drawings.

E. Perform studies using digital computer with a software package such as SKM Power*Tools for Windows™ DAPPER™, CAPTOR™ and ARC FLASH™, or approved equal.

F. Perform complete fault calculations for all busses on utility and generator power sources. Perform load flow and voltage drop studies for major feeders and loads with long feeder runs. Analysis shall include expected fault currents at industrial control panels manufactured in accordance with UL 508A and NEC article 409.

G. Fault source combinations shall include large motors, large transformers, utility and generator.

H. Utilize proposed and existing load data for the study obtained from Contract Documents and field survey. Coordinate with local power utility for available fault currents from utility services, as needed.

I. Existing Equipment:
    1. Include fault contribution of existing motors, services, generators and equipment, as appropriate, in the study.
    2. Obtain required existing equipment data from the field and FPL.

J. Provide a comprehensive report document containing the short circuit, device coordination and arc flash studies. As a minimum the report structure shall contain the following:
    1. Executive Summary.
    2. Methodology.
    3. One Line Diagram(s).
    4. Short Circuit Analysis.
    5. Short Circuit Analysis Results/Conclusions/Recommendations.
    6. Device Coordination Analysis.
    7. Recommended protective devices settings.
    8. Arc Flash Analysis.
    9. Arc Flash PPE recommendations.

2.02 SHORT CIRCUIT STUDY

A. General:
    1. Use cable impedances based on copper conductors. Use actual conductor impedances if know. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.
    2. Use bus impedances based on copper bus bars.
    3. Use cable and bus resistances calculated at 25 degrees C.
    4. Use 600-volt cable reactances based on use of typical data of conductors to be used in this project.
    5. Use transformer impedances 92.5 percent of "nominal" impedance based on tolerances specified in ANSI C57.12.00.

B. Provide:
    1. Calculation methods and assumptions.
    2. Selected base per unit quantities.
    3. One-line diagrams annotated with results of short circuit analysis including:
        a. Three phase, line-to-line and single line to ground faults.
        b. Equipment Short Circuit Rating.
    4. Source impedance data, including electric utility system and motor fault contribution characteristics.
    5. DAPPER™ Short circuit report, demand load report, load flow report and input data reports.
    6. Results, conclusions, and recommendations.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed symmetrical three-phase bolted fault, bolted line-to-ground fault, and bolted line-to-line fault at each:
    1. Electric utility's supply termination point.
    2. Main breakers, generator breakers and feeder breakers.
    3. Low voltage switchgear, switchboard and/or distribution panelboard.
    4. Unit substations.
    5. Motor control centers.
    6. Standby generator.

7. Automatic Transfer Switch (if applicable).
8. All branch circuit panelboards.
9. Variable Frequency Drives.
10. Industrial control panels manufactured in accordance with UL 508A and NEC article 409.
11. Other significant locations throughout the system.
12. Future load contributions as shown on one-line diagram.

D. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings Verify all equipment, main breakers, ATS, and protective devices are applied within their ratings.
2. Adequacy of switchgear, switchboards, motor control centers, unit substations and panelboard bus bar bracing to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating besides normal load currents.
5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

E. Through the General Contractor, furnish expected fault currents for industrial control panels, constructed and installed under other divisions and specifications of this contract, to the panel builder for his coordination with meeting the requirements of UL 508A and NEC article 409.

2.03 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves for distribution system, graphically displayed on log-log scale paper. Time Current Curve plots from SKM CAPTOR™ program are acceptable.

B. Each curve sheet to have title and one-line diagram with legend identifying the specific portion of system associated with time-current curves on that sheet.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Perform device coordination on time-current curves for low voltage distribution system(s).

F. Provide Individual protective device time-current characteristics on log-log paper or software generated graphs.

G. Plot Characteristics on Curve Sheets:
1. Electric utility's relays or protective device (if applicable).
2. Electric utility's fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands (if applicable).
3. Medium voltage equipment relays (if applicable).
4. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.

5. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
6. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
7. Transformer damage curves.
8. Conductor damage curves.
9. ANSI transformer with stand parameters.
10. Significant symmetrical and asymmetrical fault currents.
11. Ground fault protective devices and settings (if applicable).
12. Pertinent motor starting characteristics and motor damage points.
13. Pertinent generator short circuit decrement curve and generator damage point.
14. Circuit breaker panelboard main breakers, where appropriate.
15. Motor circuit protectors for major motors

H. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

I. Primary Protective Device Settings for Delta-Wye Connected Transformer:
   1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within the transformer's characteristics curve, including a point equal to 58 percent of ANSI C57.12.00 withstand point.
   2. Secondary Line-To-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

J. Separate medium voltage relay characteristics curves from curves for other devices by at least 0.4-second time margin.

2.04 ARC FLASH ANALYSIS

A. Perform incident energy calculations in accordance with IEEE 1584-2002 Guide for Performing Arc Flash Hazard Calculations for all equipment analyzed in the short circuit study. Tabular results and recommended labels from SKM ARC FLASH™ are acceptable.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, bussway and unit substations, variable frequency drives, industrial control panels) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all medium voltage, low voltage and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

I. Furnish recommendations for Personal Protective Equipment, in accordance with OSHA standards, and proper labels to be located on the electrical equipment in accordance with NEC Article 110.16.

J. Use manufacturer data for: enclosure type; gap between exposed conductors or buss way; grounding type; number of phases and connection; and working distance.

2.05 TABULATIONS

A. Input Data:
   1. Utility three-phase and line-to-ground available contribution with associated X/R ratios.
   2. Short circuit reactances of rotating machines and associated X/R ratios.
   3. Cable type, construction, size, quantity per phase, length, impedance and conduit type.
   4. Bus data, including impedance.
   5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio.

B. Short Circuit Data:
   1. Source fault impedance and generator contributions.
   2. X to R ratios.
   3. Asymmetry factors.
   4. Motor contributions.
   5. Short circuit kVA.
   6. Symmetrical and asymmetrical fault currents.

C. Recommended Protective Device Settings:
   1. Phase and ground relays:
      a. Relay name.
      b. Device number.
      c. Description.
      d. TCC catalog number.
      e. Short circuit ratings.
      f. Current transformer ratio.
      g. Current tap.
      h. Time dial setting (as applicable).
      i. Instantaneous pickup setting (as applicable).
      j. Ground fault setting (as applicable).

k. Specialty, non-overcurrent device settings.
l. Recommendations on improved relaying systems, if applicable

2. Circuit Breakers:
   a. Breaker name.
   b. Breaker Description.
   c. Model number.
   d. TCC catalog number.
   e. Short circuit rating.
   f. Frame/Sensor rating.
   g. Adjustable pickups and time delays (long time, short time, ground).
   h. Adjustable time-current characteristic.
   i. Adjustable instantaneous pickup.
   j. Recommendations on improved trip systems, if applicable
3. Motor Circuit Protectors (MCP):
   a. MCP name.
   b. MCP Description.
   c. Model number.
   d. TCC catalog number.
   e. Short circuit rating.
   f. Frame/Sensor rating.
   g. Instantaneous settings.
4. Fuses:
   a. Fuse name.
   b. Fuse Description.
   c. Model number.
   d. TCC catalog number.
   e. Short circuit rating.
   f. Fuse rating.

D. Incident energy and flash protection boundary calculations.
   1. Arcing fault magnitude
   2. Device clearing time
   3. Duration of arc
   4. Arc flash boundary
   5. Working distance
   6. Incident energy
   7. Hazard Risk Category
   8. Recommendations for arc flash energy reduction

2.06 STUDY ANALYSES

A. Written Summary:
   1. Scope of studies performed.
   2. Explanation of bus and branch numbering system.
   3. Prevailing conditions.
   4. Selected equipment deficiencies.
   5. Results of short circuit and coordination studies.
   6. Comments or suggestions.

B. Suggest changes and additions to equipment rating and/or characteristics.

C. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with the short circuit and protective device coordination studies.

C. Provide arc flash labels on all electrical equipment.

D. Notify Engineer in writing of any required major equipment modifications.

END OF SECTION

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SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. C55,1, Standard for Shunt Power Capacitors.
      b. C62.11, Standard for Metal-Oxide Surge Arrestors for AC Circuits.
      c. Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
   2. American Society for Testing and Materials (ASTM):
      a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
      b. A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
      c. A570, Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality.
   3. Federal Specifications (FS):
      a. W-C-596, Connector, Receptacle, Electrical.
      b. W-S-896E, Switches, Toggle, Flush Mounted.
   4. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
      c. CP I, Shunt Capacitors.
      d. ICS 2, Industrial Control Devices, Controllers, and Assemblies.
      e. KS 1, Enclosed Switches.
      f. LA I, Surge Arrestors.
      g. PB 1, Panelboards.
      h. ST 20, Dry-Type Transformers for General Applications.
      i. WD I, General Requirements for Wiring Devices.
   6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   7. Underwriters Laboratories, Inc. (UL):
      a. 67, Standard for Panelboards.
      b. 98, Standard for Enclosed and Dead-Front Switches.
      c. 198C, Standard for Safety High-Intermpting-Capacity Fuses, Current-Limiting Types.
      d. 198E, Standard for Class Q Fuses.
      e. 486E, Standard for Equipment Wiring Terminals.
      f. 489, Standard for Molded Case Circuit Breakers and Circuit Breaker Enclosures.
      g. 508, Standard for Industrial Control Equipment.
      h. 810, Standard for Capacitors.
      i. 943, Standard for Ground-Fault Circuit Interrupters.

j. 1059, Standard for Terminal Blocks.
k. 1561, Standard for Dry-Type General-Purpose and Power Transformers.

1.02 SUBMITTALS

A. Shop Drawings, where applicable:
1. Device boxes for use in hazardous areas.
2. Junction and pull boxes used at, or below, grade.
3. Hardware.
4. Terminal junction boxes.
5. Panelboards and circuit breaker data.
6. Fuses.
7. Contactors.
8. Transformers.
9. All other miscellaneous material part of this project.
10. Wire pulling compound.
11. Disconnects.

1.03 QUALITY ASSURANCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

B. Hazardous Areas: Materials and devices shall be specifically approved for hazardous areas of the class, division, and group shown and of a construction that will ensure safe performance when properly used and maintained.

1.04 SPARE PARTS

A. Furnish, tag, and box for shipment and storage the following spare parts:
1. Fuses, 0 to 600 Volts: Three of each type and each current rating installed.

PART 2 PRODUCTS

2.01 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.

B. Cast Aluminum:
1. Material:
    a. Box: Cast, copper-free aluminum.
    b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers:
    a. Crouse-Hinds; Type FS-SA or FD-SA.
    b. Appleton; Type FS or FD.
    c. Or approved equal.

C. Nonmetallic:
1. Box: PVC.

2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer: Carlon; Type FS or FD, with Type E98 or E96 covers, or approved equal.

2.02 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article OUTLET AND DEVICE BOXES.

B. Large Sheet Steel Box: NEMA 250, Type 1.
   1. Box: Code-gauge, 316 stainless steel.
   2. Cover: Full access, screw type.
   3. Machine Screws: Corrosion-resistant.

C. Large Stainless Steel Box: NEMA 250, Type 4X.
   1. Box: 14-gauge, ASTM A240, Type 316 stainless steel.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.
      c. Or approved equal.

D. Large Steel Box: NEMA 250, Type 4.
   1. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces, with final ANSI Z55.1, No. 61 gray enamel on exterior surfaces.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.
      c. Or approved equal.

E. Large Nonmetallic Box (only for corrosive areas and where shown):
   1. NEMA 250, Type 4X, only used for location approved by engineers.
   2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
   3. Cover: Hinged with screws.
   4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   5. Conduit hubs and mounting lugs.
   6. Manufacturers:
      a. Crouse-Hinds; Type NJB.
      b. Carlon; Series N, C, or H.
      c. Robroy Industries.
      d. Or approved equal.

2.03 WIRING DEVICES

A. Switches:
   1. NEMA WD I and FS W-S-896E.
   2. Specification grade, totally-enclosed, ac type, with quiet tumbler switches and screw terminals.

3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
4. Rating: 20 amps, 120/277 volts.
5. Color:
   a. Office Areas: Ivory.
   b. Other Areas: Brown.
6. Switches with Pilot Light: 125-volt, neon light with red jewel, or lighted toggle when switch is ON.
7. Manufacturers:
   a. Bryant.
   b. Leviton.
   c. Hubbell.
   d. Pass and Seymour.
   e. Arrow Hart.
   f. Or approved equal.

B. Receptacle, Single and Duplex:
   1. NEMA WD 1 and FS W-C-596.
   2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
   3. High strength, thermoplastic base color.
   4. Color:
      a. Office Areas: Ivory.
      b. Other Areas: Brown.
   5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
   6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
   7. Manufacturers:
      a. Bryant.
      b. Leviton.
      c. Hubbell.
      d. Pass and Seymour.
      e. Sierra.
      f. Arrow Hart.
      g. Or approved equal.

C. Receptacle, Ground Fault Circuit Interrupter: Duplex, specification grade, tripping at 5 mA.
   1. Color: Ivory.
   2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, capable of interrupting 5,000 amps without damage.
   3. Size: For 2-inch by 4-inch outlet boxes.
   4. Standard Model: NEMA WD 1 with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   5. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   6. Manufacturers:
      a. Pass and Seymour.
      b. Bryant.
      c. Leviton.
      d. Hubbell.
      e. Arrow Hart.

f. Or approved equal.

D. Receptacle, Special-Purpose:
1. Rating and number of poles as indicated or required for anticipated purpose.
2. Matching plug with cord-grip features for each special-purpose receptacle.

E. Multioutlet Surface Raceway System: Three-wire grounding receptacles, spaced on 6-inch centers with insulated grounding conductor to each receptacle.
1. Color: Gray with black receptacles.
2. Manufacturers:
a. Plugmold; 2000.
b. Walker; Duct 2GW.
c. Or approved equal.

2.04 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Plastic:
1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
2. Color: To match associated wiring device.
3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:
1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:
1. Material: Malleable ferrous metal, with gaskets.
2. Screw: Oval-head stainless steel.

E. Engraved:
1. Character Height: 3/16 inch.
2. Filler: Black.

F. Weatherproof:
1. For Receptacles: Gasketed, cast metal or stainless steel, with individual cap over each receptacle opening.
2. Mounting Screw: Stainless steel.
a. Cap Spring: Stainless steel.
b. Manufacturers:
1) General Electric.
2) Bryant.
3) Hubbell.
4) Sierra.
5) Pass and Seymour.
6) Crouse-Hinds; Type WLRD or WLRS.
7) Bell.
8) Arrow Hart.
9) Or approved equal.

3. For Switches: Gasketed, cast metal incorporating external operator for internal switch.
    a. Mounting Screw: Stainless steel.
    b. Manufacturers:
        1) Crouse-Hinds; DS-181 or DS-185.
        2) Appleton; FSK-LVTS or FSK-IVS.
        3) Or approved equal.

G. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel boxes.

2.05 LIGHTING AND POWER DISTRIBUTION PANELBOARD

A. NEMA PB I, NFPA 70, and UL 67, including panelboards installed in motor control equipment.

B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.

D. Rating: If not otherwise shown in plans. Applicable to a system with available short-circuit current of 25,000 amperes rms symmetrical at 208Y/120 or 120/240 volts and 65,000 amperes rms symmetrical at 480Y/277 volts.

E. Where ground fault interrupter circuit breakers are indicated or required by code: 5 mA trip, 10,000 amps interrupting capacity circuit breakers or as shown on plan.

F. Cabinet: As shown on plans.

G. Bus Bar:
1. Material: Copper, full sized throughout length.
2. Provide for mounting of future circuit breakers along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
3. Neutral: Insulated, rated 150 percent of phase bus bars with at least one terminal screw for each branch circuit.
4. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
5. Lugs and Connection Points:
    a. Suitable for either copper or aluminum conductors.
    b. Solderless main lugs for main, neutral, and ground bus bars.
    c. Subfeed or through-feed lugs as shown.
6. Bolt together and rigidly support bus bars and connection straps on molded insulators.

H. Circuit Breakers:
1. NEMA AB 1 and UL 489.
2. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle.
3. Noninterchangeable, in accordance with NFPA 70.
4. Locking: Provisions for handle padlocking, unless otherwise shown.

5. Type: Bolt-on circuit breakers in all panelboards.
6. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
7. Do not substitute single-pole circuit breakers with handle ties for multipole breakers.
8. Do not use tandem or dual circuit breakers in normal single-pole spaces.
9. Ground Fault Interrupter:
    a. Equip with conventional thermal-magnetic trip and ground fault sensor rated to trip in 0.025 second for a 5-milliampere ground fault (UL 943, Class A sensitivity).
    b. Sensor with same rating as circuit breaker and a push-to-test button.
10. All 480V, 3-phase panel shall have mechanism for lockable breakers.

I. Manufacturers:
1. Square D;
2. Eaton (Cutler-Hammer);
3. GE,
4. Or approved equal.

2.06 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA AB I, UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: As shown or as required.

C. Thermal-magnetic, quick-make, quick-break, indicating type, showing ON/OFF and TRIPPED indicating positions of the operating handle.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Locking: Provisions for padlocking handle.

F. Multipole breakers to automatically open all poles when an overload occurs on one-pole.

G. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

H. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position.

I. Do not provide single-pole circuit breakers with handle ties where multipole circuit breakers are shown.

2.07 NONFUSED DISCONNECT SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Enclosure: NEMA 250, Type 12, industrial use, 4X- outdoors, wet locations and corrosive areas, unless otherwise shown.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.08 FUSED DISCONNECT SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 98 listed for use and location of installation.

B. NEMA KS 1 and UL 98 Listed for application to system with available short circuit current of 22,000 amps rms symmetrical.

C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.

F. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

G. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.09 FUSE, 0 TO 600 VOLTS

A. Current-limiting, with 200,000-ampere rms interrupting rating.

B. Provide to fit mountings specified with switches and features to reject Class H fuses.

C. Motor and Transformer Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPS-RK.
      b. Littlefuse; Type LLS-RK.
      c. Or approved equal.

D. Motor and Transformer Circuits, 0- to 250-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPN-RK.
      b. Littlefuse; Type LLN-RK.
      c. Or approved equal.

E. Feeder and Service Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-I, dual element, with time delay.

3. Manufacturers:
   a. Bussmann; Type LPS-RK.
   b. Littlefuse; Type LLS-RK.
   c. Or approved equal.

F. Feeder and Service Circuits, O- to 250-Volt:
1. Amperage: 0 to 600.
2. UL 198E, Class RK-I, dual element, with time delay.
3. Manufacturers:
   a. Bussmann; Type LPN-RK.
   b. Littleluse; Type LLN-RK.
   c. Or approved equal.

G. Feeder and Service Circuits, 0- to 600-Volt:
1. Amperage: 601 to 6,000.
2. UL 198C, Class L, double O-rings and silver links.
3. Manufacturers:
   a. Bussmann; Type KRP-C.
   b. Littlefuse; Type KLPC.
   c. Or approved equal.

2.10 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCHES

A. Contact Rating: NEMA ICS 2, Type A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Lights: LED type Push-to-test, minimum 22 mm diameter.

D. Pushbutton: Only used for reset pushbutton.

E. Selector switches lockable in the OFF position where indicated.

F. Legend Plate:
1. Material: Aluminum.
2. Engraving: 11 character/spaces on one line, 14 character/spaces on each of two lines, as required, indicating specific function.
3. Letter Height: 7/64 inch.

G. Manufacturers:
1. Heavy-Duty, Oiltight Type:
   a. General Electric; Type CR 104P.
   b. Square D; Type T.
   c. Cutler-Hammer; Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Square D; Type SK.
   b. General Electric; Type CR 104P.
   c. Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.

2.11 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Terminal Blocks: Provide separate connection point for each conductor entering or leaving box.
   1. Spare Terminal Points: 25 percent.

C. Interior Finish: Paint with white enamel or lacquer.

2.12 TERMINAL BLOCK (0 TO 600 VOLTS)

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of all control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between the compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:
   1. Capable of wire connections without special preparation other than stripping.
   2. Capable of jumper installation with no loss of terminal or rail space.
   3. Individual, rail mounted.

I. Marking system allowing use of preprinted or field-marked tags.

J. Manufacturers:
   1. Weidmuller.
   2. Ideal.
   3. Electrovert.
   4. Or approved equal.

2.13 MAGNETIC CONTROL RELAY

A. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control with field convertible contacts.

B. Time Delay Relay Attachment:
   1. Pneumatic type, timer adjustable from 0.2 to 60 seconds (minimum).
   2. Field convertible from ON delay to OFF delay and vice versa.

C. Latching Attachment: Mechanical latch having unlatching coil and coil clearing contacts.

D. Manufacturers:
   1. Cutler-Hammer; Type M-600.
   2. General Electric; Type CR120B.
   3. Or approved equal.

2.14 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush, panel.

D. Manufacturers:
   1. General Electric; Type 240, 2-1/2-inch Big Look.
   2. Eagle Signal; Bulletin 705.
   3. Or approved equal.

2.15 MAGNETIC CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated, electrically held.

C. Main Contacts:
   1. Power driven in one direction with gravity dropout.
   2. Silver alloy with wiping action and arc quenchers.
   3. Continuous-duty, rated 30 amperes, 600-volt.
   4. Three-pole.

D. Control: Two-wire.

E. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

F. Enclosure: NEMA 250, Type 12, unless otherwise shown.

G. Manufacturers:
   1. Westinghouse; Class A211.
   2. General Electric; CR 353.
   3. Allen-Bradley; Bulletin 500 Line.
   4. Or approved equal.

2.16 MAGNETIC LIGHTING CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in both OPEN and CLOSED position.

D. Main Contacts:
   1. Power driven in both directions.
   2. Double-break, continuous-duty, rated 20 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
   3. Marked for electric discharge lamps, tungsten, and general-purpose loads.
   4. Position not dependent on gravity, hooks, latches, or semi-permanent magnets.

5. Capable of operating in any position.
6. Visual indication for each contact.

E. Auxiliary contact relay for three-wire control.

F. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

G. Fully rated neutral plate.

H. Provision for remote pilot lamp with use of auxiliary contacts.

I. Clamp type, self-rising terminal plates for solderless connections.

J. Enclosure: NEMA 250, Type 12, Dust-Tight, Drip-Tight, Industrial Use, unless otherwise shown.

K. Manufacturers:
1. ASCO.
2. Westinghouse; Class A202.
3. General Electric; Class 360.

2.17 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Self-cooled, two-winding, UL K-4 rated for nonlinear loads.

C. Insulation Class and Temperature Rise: Manufacturer's standard.

D. Core and Coil:
1. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

E. Enclosure:
1. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated.
2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor or Wet location (process area) Transformers: NEMA 250, Type 3R.

F. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA.

G. Voltage Taps:
1. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

H. Impedance: 4.5 percent minimum on units 75 kVA and larger.

I. Maximum Sound Level: NEMA ST 20:
1. 40 decibels for 0 to 9 kVA.
2. 45 decibels for 10 to 50 kVA.
3. 50 decibels for 51 to 150 kVA.
4. 55 decibels for 151 to 300 kVA.
5. 60 decibels for 301 to 500 kVA.

J. Vibration Isolators:
1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

K. Manufacturers:
1. Eaton ;
2. Square D;
3. GE;
4. Or approved equal.

2.18 LOW VOLTAGE, SECONDARY SURGE PROTECTIVE EQUIPMENT

A. NEMA LA1, ANSI C62. 11.

B. Surge Capacitor:
1. Impregnated with non-PCB, biodegradable dielectric fluid.
2. Integral discharge resistor which will drain residual voltage to 50 volts crest in less than I minute after disconnection from circuit.

C. Arrestor: High strength metal oxide valve elements enclosed in high strength, corrosion resistant, molded resin housing.

D. Equip capacitor and arrestor with mounting nipple, flat washer, and nut suitable for knockout or bracket mounting.

2.19 SUPPORT AND FRAMING CHANNELS

A. Material:
1. Dry indoors - galvanized.
2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required. Fiber-reinforced epoxy shall be only used where shown on drawings.

B. Finish:
   1. Dry indoors - galvanized.
   2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required. Fiber-reinforced epoxy shall be only used where shown on drawings.

C. Inserts: Continuous.

D. Beam Clamps: 316 stainless steel. All hinges and hardware shall be 316 stainless steel.

E. Manufacturers:
   1. B-Line.
   2. Unistrut.
   3. Or approved equal.

2.20 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White, engraved to a black core.

D. Engraving:
   1. Pushbuttons/Selector Switches: Name of drive controlled on one, two, or three lines, as required.
   2. Panelboards: Panelboard designation, service voltage, and phases.

E. Letter Height:
   1. Pushbuttons/Selector Switches: 1/8 inch.
   2. Panelboards: 1/4 inch.

2.21 SURGE PROTECTIVE DEVICES

A. This section describes the material and installation requirements for surge protection devices (SPD) in switchboards, panelboards, and motor control centers for the protection of all AC electrical circuits.

B. SPD’s shall be listed and component recognized in accordance with UL 1449 3rd addition Type 1 SPD and UL 1283.

C. SPD’s shall be installed and warranted by and shipped from the electrical distribution equipment manufacturer’s factory.

D. SPD’s shall provide surge current diversion paths for all modes of protection; L-L, L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.

E. SPD’s shall be modular in design. Each module shall be fused with a surge rated fuse.

F. A UL approved disconnect switch shall be provided as a means of disconnect in the switchboard device only.

G. SPD’s shall meet or exceed the following criteria:
    1. Maximum surge current capability (single pulse rated) shall be:
        a. Service entrance switchboard 300kA per phase, non-service entrance rated switchboard: 240kA per phase
        b. Branch panelboards 150kA per phase
        c. Motor control centers 80kA per phase
    2. UL 1449 3rd edition Listed and Recognized Component Voltage Protection Ratings shall not exceed the following:

Voltage	L-N	L-G	N-G
208Y/120	600V	600V	600V
480Y/277	1000V	1000V	1000V

H. SPD’s shall have a minimum EMI/RFI filtering of -44dB at 100kHz with an insertion ration of 50:1 using MIL STD. 220A methodology.

I. SPD’s shall be provided with 1 set of NO/NC dry contacts.

J. SPD’s shall have a warranty for a period of five years, incorporating unlimited replacements of suppressor parts if transients destroy them during the warranty period. Warranty will be the responsibility of the electrical distribution equipment manufacturer.

K. Approve manufactures are:
    1. Cutler Hammer
    2. General Electric
    3. Siemans
    4. Square D Company
    5. Current Technology
    6. No approved or equal.

2.22 POWER METER

A. Solid-state device with LED displays.

B. Direct voltage input up to 600 volts ac.

C. Current input via current transformer with 5-ampere secondary.

D. Programmable current and potential transformer ratios.

E. Programmable limits to activate up to four alarms.

F. Selectable voltage measurements; line-to-line or line-to-neutral, and wye or delta.

G. Simultaneous Display:
    1. Volts, three-phase.
    2. Amperes, three-phase.
    3. Kilowatts.
    4. Kilowatt-hours.
    5. Power factor.
    6. Frequency.
    7. kW demand, with programmable period intervals.
    8. kVA, kVAR, kVARh.

9. Ground leakage mA.
10. THD.
11. K-factor.

H. Voltage Rating: 95 to 135 volts, ac.

I. Individual voltage, current, and kW 4-20 mA output. KYZ pulse output representing units of energy.

J. Power meter shall communicate over EtherNet communications protocol.

K. Manufacturers:
   1. Eaton (Cutler-Hammer).
   2. GE.
   3. Square D.
   4. Or Owner/Engineer Approved Equal.

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with NECA 5055.

3.02 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in the wiring or raceway system, sized to meet NFPA 70 requirements.

B. Size:
   1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
      a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
   2. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
   3. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

C. Locations:
   1. Drawing locations are approximate.
   2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by ENGINEER.
   3. Light Switch: Install on lock side of doors.
   4. Light Fixture: Install in symmetrical pattern according to room layout unless otherwise shown.

D. Mounting Height:
   1. General:
      a. Measured to centerline of box.
      b. Where specified heights do not suit building construction or finish, mount as directed by ENGINEER.
   2. Light Switch: 48 inches above floor.
   3. Thermostat: 54 inches above floor.

4. Telephone Outlet: 6 inches above counter tops or 15 inches above floor.
5. Wall Mounted Telephone Outlet: 52 inches above floor.
6. Convenience Receptacle:
    a. General Interior Areas: 15 inches above floor.
    b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above countertops without splashback.
    c. Industrial Areas, Workshops: 48 inches above floor.
    d. Outdoor, All Areas: 24 inches above finished grade.
7. Special-Purpose Receptacle: 54 inches above floor or as shown.

E. Install plumb and level.

F. Flush Mounted:
1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws threaded into steelwork.

I. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

J. Provide plaster rings where necessary.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. Install stainless steel mounting hardware in industrial areas.

M. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

N. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

O. Box Type (Steel Raceway System):
1. Exterior Locations:
    a. Exposed Raceways: Cast metal.
    b. Concealed Raceways: Cast metal.
    c. Concrete Encased Raceways: Cast metal.
    d. Class I, II, or III Hazardous Areas: Cast metal.
2. Interior Dry Locations:
    a. Exposed Rigid Conduit: Cast metal.
    b. Exposed EMT: Sheet steel.
    c. Concealed Raceways: Sheet steel.
    d. Concrete Encased Raceways: Cast metal.
    e. Lighting Circuits, Ceiling: Sheet steel.

f. Class I, II, or III Hazardous Areas: Cast metal.

3. Interior Wet Locations:
   a. Exposed Raceways: Cast metal.
   b. Concealed Raceways: Cast metal.
   c. Concrete Encased Raceways: Cast metal.
   d. Lighting Circuits, Ceiling: Sheet steel.
   e. Class I, II, or III Hazardous Areas: Cast metal.
4. Cast-In-Place Concrete Slabs: Sheet steel.

P. Box Type (Rigid Aluminum Raceway System): Cast aluminum.

Q. Box Type (Nonmetallic Raceway System):
   1. Corrosive Locations: Nonmetallic.
   2. Exposed Raceways: Nonmetallic.
   3. Concealed Raceways: Nonmetallic.
   4. Concrete Encased Raceways: Nonmetallic.

3.03 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

E. Installed boxes shall be accessible.

F. Do not install on finished surfaces.

G. Install plumb and level.

H. Support boxes independently of conduit by attachment to building structure or structural member.

I. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded threaded studs on steelwork.

J. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. Above Grade:
   1. Install above grade pullbox on concrete pad as shown on details. All mounting hardware shall be 316 stainless steel.

M. Flush Mounted:
 1. Install with concealed conduit.
 2. Holes in surrounding surface shall be no larger than required to receive box.
 3. Make edges of boxes flush with final surface.

N. Mounting Hardware:
 1. Noncorrosive Interior Areas: Galvanized.
 2. All Other Areas: Stainless steel.

O. Location/Type:
 1. Finished, Indoor, Dry: NEMA 250, Type 1.
 2. Unfinished, Indoor, Dry: NEMA 250, Type 12.
 3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
 4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
 5. Unfinished, Indoor and Outdoor, Hazardous: NEMA 250, Type 7 and Type 9, where indicated.
 6. Underground Conduit: Concrete Encased.
 7. Corrosive Locations: Nonmetallic.

3.04 WIRING DEVICES

A. Switches:
 1. Mounting Height: See Paragraph OUTLET AND DEVICE BOXES.
 2. Install with switch operation in vertical position.
 3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:
 1. Install with grounding slot down except where horizontal mounting is shown, in which case install with neutral slot up.
 2. Ground receptacles to boxes with grounding wire only.
 3. Weatherproof Receptacles:
    a. Install in cast metal box.
    b. Install such that hinge for protective cover is above receptacle opening.
 4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.
 5. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.

C. Multioutlet Surface Raceway System:
 1. Install in accordance with manufacturer's instructions.
 2. Wire alternate outlets to each circuit where two-circuit, three-wire supply is shown.

3.05 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to the box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be an acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Engrave with designated titles.

F. Types (Unless Otherwise Shown):
   1. Office: Stainless Steel.
   2. Exterior: Weatherproof.
   3. Interior:
      a. Flush Mounted Boxes: Stainless Steel.
      b. Surface Mounted, Cast Metal Boxes: Cast metal.
      c. Surface Mounted, Sheet Steel Boxes: Stainless Steel.
      d. Surface Mounted, Nonmetallic Boxes: Plastic.

3.06 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Heavy-Duty, Oiltight Type: Locations (Unless Otherwise Shown): Nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   1. Locations (Unless Otherwise Shown): Nonhazardous, outdoor, or normally wet areas.
   2. Mounting: NEMA 250, Type 4X enclosure.

3.07 TERMINAL JUNCTION BOX

A. Install in accordance with Paragraph JUNCTION AND PULL BOXES.

B. Label each block and terminal with permanently attached, nondestructible tag.

C. Do not install on finished outdoor surfaces.

D. Location:
   1. Finished, Indoor, Dry: NEMA 250, Type 1.
   2. Unfinished, Indoor, Dry: NEMA 250, Type 12.
   3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
   4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.

3.08 LIGHTING AND POWER DISTRIBUTION PANELBOARD

A. Install securely, plumb, in-line and square with walls.

B. Install top of cabinet 6 feet above floor unless otherwise shown.

C. Provide typewritten circuit directory for each panelboard.

3.09 SUPPORT AND FRAMING CHANNEL

A. Furnish zinc-rich primer; paint cut ends prior to installation, where applicable.

B. Install where required for mounting and supporting electrical equipment and raceway systems.

3.10 MOTOR SURGE PROTECTION

A. Ground in accordance with NFPA 70.

B. Low Voltage: Ground terminals to equipment bus.

END OF SECTION

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SECTION 16110

RACEWAYS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): Division I, Standard Specifications for Highway Bridges, Fourteenth Edition.
2. American National Standards Institute (ANSI):
   a. C80.1, Rigid Steel Conduit-Zinc Coated.
   b. C80.3, Electrical Metallic Tubing-Zinc Coated.
   c. CS0.5, Rigid Aluminum Conduit.
   d. C80.6, Intermediate Metal Conduit (IMC)-Zinc Coated.
3. American Society for Testing and Materials (ASTM):
   a. A123 EI, Standard Specification for Zinc-Coated (Galvanized) Coatings on Iron and Steel Products.
   b. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
4. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation.
5. National Electrical Manufacturers Association (NEMA):
   a. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   b. TC 2, Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
   c. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
   d. TC 6, PVC and ABS Plastic Utilities Duct for Underground Installation.
   e. VE 1, Metallic Cable Tray Systems.
6. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
7. Underwriters Laboratories, Inc. (UL):
   a. 1, Standard for Safety Flexible Metal Conduit.
   b. 6, Standard for Safety Rigid Metal Conduit.
   c. 360, Standard for Safety Liquid-Tight Flexible Steel Conduit.
   d. 514B, Standard for Safety Fittings for Conduit and Outlet Boxes.
   e. 514C, Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
   f. 651, Standard for Safety Schedule 40 and 80 PVC Conduit.
   g. 651A, Standard for Safety Type EB and Rigid PVC Conduit and HDPF Conduit.
   h. 797, Standard for Safety Electrical Metallic Tubing.
   i. 870, Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings.
   j. 1242, Standard for Safety Intermediate Metal Conduit.
   k. 1660, Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit.

1.02 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's Literature:
      a. Electric metallic tubing.
      b. Rigid aluminum conduit.
      c. PVC Schedule 40 conduit.
      d. PVC Schedule 80 conduit.
      e. Flexible metal, liquid-tight conduit.
      f. Flexible, nonmetallic, liquid-tight conduit.
      g. Conduit fittings.
      h. Wireways.
   2. Precast Manholes and Handholes:
      a. Dimensional drawings and descriptive literature.
      b. Traffic loading calculations.
      c. Accessory information.
   3. Cable Tray Systems:
      a. Dimensional drawings, calculations, and descriptive information.
      b. NEMA load/span designation and how it was selected.
      c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
      d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
      e. Layout drawings and list of accessories being provided.
   4. Conduit Layout:
      a. Plan and section type, showing arrangement and location of conduit and duct bank required for:
         1) Low and medium voltage feeder and branch circuits.
         2) Instrumentation and control systems.
         3) Communications systems.
         4) Empty conduit for future use.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Electric Metallic Tubing (EMT), not used:

   1. Meet requirements of ANSI C80.3 and UL 797.
   2. Material: Hot-dip galvanized, with chromated and lacquered protective layer.

B. Rigid Aluminum Conduit:
   1. Meet requirements of ANSI C80.5 and UL 6.
   2. Material: Type 6063, copper-free aluminum alloy.

C. PVC Schedule 40/80 Conduit:
   1. Meet requirements of NEMA TC 2 and UL 651.

2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

D. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of NEMA RN 1.
   2. Material:
      a. Conduit: Meet requirements of ANSI C80.1 and UL 6
      b. PVC Coating: 40 mils nominal thickness, bonded to metal.

E. Flexible Metal, Liquid-Tight Conduit:
   1. UL 360 listed for 105 degrees C insulated conductors.
   2. Material: Galvanized steel, with an extruded PVC jacket.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:
   1. Material: PVC core with fused flexible PVC jacket.
   2. UL 1660 listed for:
      a. Dry Conditions: 80 degrees C insulated conductors.
      b. Wet Conditions: 60 degrees C insulated conductors.
   3. Manufacturers:
      a. Carlon; Carflex or X-Flex.
      b. T & B; Xtraflex LTC or EFC.
      c. Or approved equal.

2.02 FITTINGS

A. Electric Metallic Tubing:
   1. Meet requirements of UL 514B.
   2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
   3. Compression Ring: Stainless steel.
   4. Coupling Manufacturers:
      a. Appleton; Type 95T.
      b. Crouse-Hinds; Type CPR.
      c. Or approved equal.
   5. Connector Manufacturers:
      a. Appleton; Type 86T.
      b. Crouse-Hinds; Type CPR.
      c. Or approved equal.

B. Rigid Aluminum Conduit:

   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, copper-free. Set screw fittings not permitted.
   2. Insulated Bushing:
      a. Material: Cast aluminum, with integral insulated throat, and rated for 150 degrees C.
      b. Manufacturer: O.Z. Gedney; Type AB or approved equal.
   3. Grounding Bushing:
      a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
      b. Manufacturer: O.Z. Gedney; Type ABLG or approved equal.

4. Conduit Hub:
   a. Material: Cast aluminum, with insulated throat.
   b. Manufacturers:
      1) O.Z. Gedney; Type CHA.
      2) T & B; Series 370AL.
      3) Or approved equal.
5. Conduit Bodies:
   a. Manufacturers (For Normal Conditions):
      1) Appleton; Form 85 threaded Unilets.
      2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
      3) Killark; Series O Electrolets.
   b. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting Manufacturers:
   a. Appleton; Type EYF-AL or EYM-AL.
   b. Crouse-Hinds; Type EYS-SA or EZS-SA.
   c. Killark; Type EY or EYS.
8. Drain Seal Manufacturers:
   a. Appleton; Type EYDM-A.
   b. Crouse-Hinds; Type EYD-SA or EZD-SA.
   c. Or approved equal.
9. Drain/Breather Fitting Manufacturers:
   a. Appleton; Type ECDB.
   b. Crouse-Hinds; ECD.
   c. Or approved equal.
10. Expansion Fitting Manufacturers:
   a. Deflection/Expansion Movement: Steel City; Type DF-A.
   b. Expansion Movement Only: Steel City; Type AF-A.
   c. Or approved equal.
11. Cable Sealing Fittings: To form watertight nonslip cord or cable connection to conduit.
   a. Bushing: Neoprene at connector entry.
   b. Manufacturer: Appleton CG-S.
   c. Or approved equal.

C. PVC Conduit and Tubing:
   1. Meet requirements of NEMA TC-3.
   2. Type: PVC, slip-on.

D. Flexible Metal, Liquid-Tight Conduit:
   1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
   2. Insulated throat and sealing O-rings.
   3. Long design type extending outside of box or other device at least 2 inches.
   4. Manufacturer: T & B; Series 5300 or approved equal.

E. Flexible, Nonmetallic, Liquid-Tight Conduit: Meet requirements of UL 514B.
   1. Type: One-piece fitting body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.

2. Manufacturers:
    a. Carlon; Type LT.
    b. Kellems; Polytuff.
    c. T & B; LT Series.
    d. Or approved equal.

F. Watertight Entrance Seal Device:
1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer: O.Z./Gedney; Type FSK or WSK, as required or approved equal.
2. Gored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer: O.Z./Gedney; Series CSM or approved equal.

G. Hazardous Locations: Approved for use in the atmosphere involved.
1. Manufacturer: Crouse-Hinds; Type ECGJH or approved equal.

2.03 WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, with removable, hinged cover.

C. Rating: Outdoor raintight if outdoor, and indoor if indoor.

D. Finish: Gray, baked enamel for indoor, 316 stainless steel for outdoor.

E. Manufacturers:
1. Square D.
2. B-Line Systems, Inc.
3. Or approved equal.

2.04 CABLE TRAYS

A. Not used.

2.05 ABOVE GROUND PULLBOX

A. See Electrical Drawings.

2.06 ACCESSORIES

A. Duct Bank Spacers:
1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
2. Suitable for all types of conduit.
3. Manufacturer: Underground Device, Inc.; Type WUNPEECE or approved equal.

B. Identification Devices:
1. Raceway Tags:
    a. Material: Permanent, nylon.

b. Shape: Round.
c. Raceway Designation: Pressure stamped, embossed, or engraved.
d. Tags relying on adhesives or taped-on markers not permitted.

2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge.
   b. Color: Red.
   c. Width: Minimum 6-inch.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Manufacturers:
      1) Blackburn, Type RT.
      2) Griffolyn Co.
      3) Or approved equal
3. Buried Raceway Marker:
   a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
   b. Designation: Incise to depth of 3/32 inch, ELECTRIC CABLES, in letters 1/4-inch high.
   c. Minimum Dimension: 1/4-inch thick, 10 inches long, and 3/4-inch wide.

C. Raceway Coating:
   1. Material: Heat shrink tubing.
   2. Manufacturers:
      a. Raychem; Type BSTS/BSTS-FR.
      b. Or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and Tubing sizes shown are based on the use of copper conductors. Reference Section 16120, CONDUCTORS, concerning conduit sizing for aluminum conductors.

B. All installed Work shall comply with NECA 5055.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Aluminum Conduit: Do not install in direct contact with concrete or earth. Provide and install unistrut between concrete and Aluminum or install heat shrink tubing to the conduit. For conduit transition from underground (PVC) to aboveground application (Rigid Aluminum), install heat shrink tubing on conduit. Heat shrink shall cover the underground conduit adapter and extend at least 6 inches above ground.

G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

I. Group raceways installed in same area.

J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

M. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.

N. Install watertight fittings in outdoor, underground, or wet locations.

O. All metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

3.02 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum cover 1-1/2 inches, unless otherwise noted.

B. Provide support during placement of concrete to ensure raceways remain in position.

C. Floor Slabs:
1. Conduit installed 18 inches below slab, encased in concrete.
2. Conduits installed less than 18 below slab, concrete incased and have hooks to tie the duct bank to the slab.
3. Outside diameter of conduit not to exceed one-third of the slab thickness.
4. Separate conduit by minimum six times conduit outside diameter, except at crossings.

3.03 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed:
1. Rigid Aluminum.

C. Interior, Exposed:
1. Rigid Aluminum.

D. Interior, Concealed (Not Embedded in Concrete):

1. Rigid Aluminum.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

F. Concrete Slab on Top or concrete encased: PVC Schedule 40.

G. Under Slabs-On-Grade: PVC Schedule 40.

H. Corrosive Areas: PVC Schedule 80.

I. Lightning Protection: PVC Schedule 40.

3.04 CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
   1. Conduit Size 4 Inches or Less: Flexible metal, liquid-tight conduit.
   2. Conduit Size Over 4 Inches: Nonflexible.
   3. Corrosive Areas: Flexible, nonmetallic, liquid-tight.
   4. Length: 18-inch minimum, 60-inch maximum, of sufficient length to allow movement or adjustment of equipment.

B. Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Transition From Underground or Concrete Embedded to Exposed: Heat shrink coated Rigid Aluminum conduit or PVC coated Aluminum.

E. Under floor mounted electrical equipment: PVC schedule 40 with end bell.

F. Exterior Light Pole Foundations: PVC schedule 40.

3.05 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Fire-stop openings around penetrations to maintain fire-resistance rating.

D. Apply heat shrink tubing to all metallic conduit in contact with concrete floor slabs to a point 6 inches above concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

F. Entering Structures:
1. Membrane Waterproofed Wall or Floor:
   a. Provide a watertight seal.
   b. Without Concrete Encasement: Install watertight entrance seal device on each side.
   c. With Concrete Encasement: Install watertight entrance seal device on the accessible side.
   d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
   e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
   f. Conduit penetration of roof is not allowed.
2. Heating, Ventilating, and Air Conditioning Equipment:
   a. Penetrate equipment in area established by manufacturer.
   b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
3. Corrosive-Sensitive Areas:
   a. Seal all conduit passing through chlorine and ammonia room walls.
   b. Seal all conduit entering equipment panel boards and field panels containing electronic equipment.
   c. Seal penetration with silicone type sealant as specified in Section FIRE STOPPING.
4. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device.
5. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
   a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
   b. Fill space between raceway and sleeve with an expandable plastic compound on each side.
6. Manholes and Handholes:
   a. Metallic Raceways: Provide insulated grounding bushings.
   b. Nonmetallic Raceways: Provide bell ends flush with wall.
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.06 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 40 percent extra space for future conduit.

C. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
1. Wood: Wood stainless steel screws.
2. Hollow Masonry Units: Toggle stainless steel bolts.
3. Concrete or Brick: Expansion shields, or stainless steel tapcon.
4. Steelwork: Machine stainless steel screws.

D. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.07 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:
   1. Bends 30-Degree and Larger: Provide factory-made elbows.
   2. 90-Degree Bends: Provide pvc coated rigid steel elbows.
   3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.08 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.09 PVC CONDUIT

A. Solvent Welding:
   1. Provide manufacturer recommended solvent; apply to all joints.
   2. Install such that joint is watertight.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type.
   2. PVC to Rigid Aluminum Conduit: PVC female adapter.

C. Belied-End Conduit: Bevel the unbelled end of the joint prior to joining.

3.10 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

3.11 CABLE TRAYS

A. Install in accordance with Application Information Section of NEMA VE 1.

B. Provide accessories as necessary for a complete system.

C. Install such that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for all horizontal cable tray.

F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Provide expansion joints in accordance with NEMA VE 1 for 50 degrees F maximum temperature variation.

H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.

I. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

J. Install without exposed raw edges.

K. Maintain 9-inch vertical separation between multi-tiered trays having a common support, and at all crossover locations.

L. Provide bonding jumper at each expansion joint and adjustable connection.

M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.12 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Sheet Metal Boxes, Cabinets, and Enclosures:
1. Rigid Aluminum Conduit:
    a. Provide one lock nut each on inside and outside of enclosure.
    b. Install grounding bushing.
    c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.
    d. Install insulated bushing on ends of conduit where grounding is not required.
    e. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
2. Electric Metallic Tubing: Provide gland compression, insulated connectors.
3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.

4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
5. PVC Schedule 40/80 Conduit: Provide PVC terminal adapter with lock nut.

3.13 UNDERGROUND RACEWAYS

A. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

B. Make routing changes as necessary to avoid obstructions or conflicts.

C. Couplings: In multiple conduit runs, stagger so that couplings in adjacent runs are not in same transverse line.

D. Union type fittings not permitted.

E. Spacers:
1. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

F. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

G. Installation with Other Piping Systems:
1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

H. Concrete Encasment: As specified in Section CAST-IN-PLACE CONCRETE.
1. Concrete Color: Gray, dust top of concrete ductbank with powdered red concrete dye before concrete sets and trowel dry onto top of ductbank.

I. Backfill:
1. As specified in Section EARTHWORK.
2. Do not backfill until inspected by ENGINEER.

3.14 ABOVED GROUND PULLBOX

B. A. Install above ground pullbox on concrete slab as per details.

C. B. Grounding: As specified in Section 16450, GROUNDING.

D. C. Identification: Provide equipment tag as per Section, 16050.

3.15 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells for PVC conduits, matching metallic cap for metallic conduits.

C. Provide nylon pull cord.

D. Identify, as specified in Paragraph IDENTIFICATION DEVICES, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.16 IDENTIFICATION DEVICES

A. RacewayTags:
1. Identify origin and destination.
2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
3. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

C. Buried Raceway Markers:
1. Install at grade to indicate direction of underground raceways.
2. Install at all bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.17 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over all conduit openings during construction.

END OF SECTION

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SECTION 16120

CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American National Standards Institute (ANSI): 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   2. American Society for Testing and Materials (ASTM):
      a. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel-P1ated Steel Plate, Sheet, and Strip.
      b. B3, Standard Specification for Soft or Annealed Copper Wire.
      c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
      d. B263, Standard Test Method for Determination of Cross- Sectional Area of Stranded Conductors.
   3. Association of Edison Illuminating Companies (AEIC):
      a. AEIC CS8 Specification for Extruded Dielectric Shield Power Cables rated 5 through 46 kV
   4. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 48, Standard Test Procedures and Requirements or High-Voltage Alternating Current Cable Terminations.
      b. 404, Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5,000V through 46,000V and Cable Joints for Use with Laminated Dielectric Cable Rated 2,500V through 500,000V.
      c. 1202, Flame-Propagation Testing of Wire and Cables.
   5. National Electrical Contractors Association, Inc. (NECA): 5055, Standard of Installation.
   6. National Electrical Manufacturers' Association (NEMA):
      a. CC 1, Electric Power Connectors for Substations.
      b. WC 70, Power Cables rated 2000V or less for Distribution of Electrical Energy
      c. WC 74, 5-46kV Shielded Power Cable for Use in Distribution of Electrical Energy.
      d. WC 57, Standard for Control, Instrumentation, and Thermocouple Cable.
   7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   8. Underwriters Laboratories, Inc. (UL):
      a. 13, Standard for Safety Power-Limited Circuit Cables.
      b. 44, Standard for Safety Rubber-Insulated Wires and Cables.
      c. 62, Standard for Safety Flexible Cord and Fixture Wire.
      d. 486A, Standard for Safety Wire Connector and Soldering Lugs for Use with Copper Conductors.
      e. 486B, Standard for Safety Wire Connectors and Soldering Lugs for Use with Aluminum Conductors.
      f. 510, Standard for Safety Insulating Tape.
      g. 854, Standard for Safety Service-Entrance Cables.

h. 910, Standard for Safety Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air Handling Spaces.
i. 1072, Standard for Safety Medium-Voltage Power Cables.
j. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
k. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Shop Drawings:
1. Wire and cable descriptive product information.
2. Wire and cable accessories descriptive product information.
3. Cable fault detection system descriptive product information.
4. Manufactured wiring systems descriptive product information.
5. Manufactured wire systems rating information.
6. Manufactured wire systems dimensional drawings.
7. Manufactured wire systems special fittings.
8. Busway descriptive product information.
9. Busway rating information.
10. Busway dimensional drawings.
11. Busway special fitting information.
12. Busway-equipment interface information for equipment to be connected to busways.

B. Quality Control Submittals:
1. Certified Factory Test Report for conductors 600 volts and below.
2. Certified Factory Test Report per AEIC CS6, including AEIC qualification report for conductors above 600 volts.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:
1. 120- and 277-Volt Lighting, No. 10 AWG and Smaller: Stranded copper.
2. 120-Volt Receptacle Circuits, No. 10 AWG and Smaller: Stranded copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN, except for sizes No. 6 and larger, with XHHW insulation.

D. Direct Burial and Aerial Conductors and Cables:
1. Type USE/RHH/RHW insulation, UL t (54 listed, Type RHW-2/USE-2.

2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:
   1. Type SOW with ethylene propylene rubber insulation in accordance with UL 62.
   2. Conform to physical and minimum thickness requirements of NEMA WC 70.

F. Cable Tray Conductors and Cables: Type TC.

2.02 600-VOLT RATED CABLE

A. General:
   1. Type: TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725.
   2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   3. Suitable for installation in open air, in cable trays, or conduit.
   4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
   5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Wire and Connectors:
   1. Cable shall be rated for 600 volts and shall meet the requirements below:
   2. Conductors shall be stranded
   3. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
   4. Type of wire shall be XHHW or THHN, rated 75 degrees C suitable for wet locations except where required otherwise by the drawings.
   5. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
   6. Conductor metal shall be copper.
   7. All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.

C. Type I-Multiconductor Control Cable:
   1. Conductors:
      a. No. 14 AWG, seven-strand copper.
      b. Insulation: 15-mil PVC with 4-mil nylon.
      c. UL 1581 listed as Type THHN/THWN rated VW-I.
      d. Conductor group bound with spiral wrap of barrier tape.
      e. Color Code: In accordance with NEMA WC 5, Method 1, and Sequence K-2.
   2. Cable: Passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
   3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (inches)	Jacket Thickness (mils)
3	0.41	45
5	0.48	45
7	0.52	45

No. of Conductors	Max. Outside Diameter (inches)	Jacket Thickness (mils)
12	0.72	60
19	00.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Rome Cable.
   c. General Cable.
   d. Or approved equal.

D. Type 2-Multiconductor Power Cable:
1. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically crosslinked ethylene-propylene with Hypalon jacket.
   c. UL 1581 listed as Type EPR, rated VW-1.
   d. Color Code: Conductors, size No. 8 AWG and smaller, colored conductors, NEMA WC5 Method 1, color 5 per Article POWER CONDUCTOR COLOR CODING. Conductors, size No. 6 AWG and larger, NEMA WC5, Method 4.
2. Cable pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max.Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45 45 45
10	10	2 3 4	0.54 0.58 0.63	60 60 60
8	10	3 4	0.66 0.72	60
6	8	3 4	0.74 0.81	60
4	6	3 4	0.88 0.97	60 80
2	6	3 4	1.01 1.11	80
1/0	6	3 4	1.22 1.35	80
2/0	4	3 4	1.32 1.46	80
4/0	4	3 4	1.56 1.78	80

4. Manufacturers:
   a. Okonite Co.
   b. Pome Cable.
   c. Or approved equal.

E. Type B-No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1. Outer Jacket: 45-mil nominal thickness.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   3. Dimension: 0.31-inch nominal OD.
   4. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8
      b. 20 AWG, seven-strand tinned copper drain wire.
      c. Insulation: 15-mil nominal PVC.
      d. Jacket: 4-mil nominal nylon.
      e. Color Code: Pair conductors black and red.
   5. Manufacturers:
      a. Okonite Co.
      b. Alpha Wire Corp.
      c. Or approved equal.
   6. The following test shall be performed on instrumentation and control system cables. All tests shall be end-to-end test of installed cables with the ends supported in free air, not adjacent to any ground object. All test data shall be recorded on forms acceptable to the Engineer. Complete records of all tests shall be made and delivered to the Engineer.
      a. Continuity tests shall be performed by measuring wire/shield loop resistances of signal cable as the wires, taken one at a time, are shorted to the channel shield. No loop resistance measurement shall carry by more than $\underline{+}2$ ohms from the calculated average loop resistance valve.
      b. Insulation resistance tests shall be performed by using a 500 volt megohmeter to measure the insulation resistance between each channel wire and channel shield, between individual channel shields in a multi-channel cable, between each individual channel and the overall cable shield in multi-channel cable, between each wire and ground, and between each shield and ground. Values of resistance less than 10 megohms shall be unacceptable.

F. Type B1-No. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1. Outer Jacket: 45-mil nominal.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
   3. Dimension: 0.32-inch nominal OD.
   4. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      b. 20 AWG, seven-strand, tinned copper drain wire.

c. Insulation: 15-mil nominal PVC.
d. Jacket: 4-mil nylon.
e. Color Code: Triad conductors black, red, and white.

5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Or approved equal.

G. Type B2-No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.
   1. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8
      b. Tinned copper drain wires.
      c. Pair drain wire size AWG 20, group drain wire size AWG 18.
      d. Insulation: 15-mil PVC.
      e. Jacket: 4-mil nylon.
      f. Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
      g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
   2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
   3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (inches)	Nominal Jacket Thickness (mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

   4. Manufacturers:
      a. Okonite Co.
      b. Alpha Wire Corp.
      c. Or approved equal.

H. Type B3-No. 18 AWG, Multi-twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.
   1. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
      b. Tinned copper drain wire size 18 AWG
      c. Insulation: 15-mil nominal PVC.
      d. Jacket: 4-mil nylon.

e. Color Code: Pair conductors black and red, with red conductor numerically printed for group identification.

2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3. Cable Sizes:

Number Of Pairs	Maximum Outside Diameter (inches)	Nominal Jacket Thickness (mils)
4	0.46	45
8	0.63	60
12	0.75	60
16	0.83	60
24	1.06	80
36	1.21	80
50	1.42	80

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Or approved equal.

I. Ethernet Cat. 6e UTP Cable (Copper):
1. Section applies to all Ethernet Cable (Copper) except for Fiber Optic cable.
2. Conductor Physical Characteristics: 4 twisted pairs (8 conductors), 23 AWG solid bare Copper with Polyolefin Insulation. Overall Nominal Diameter: 0.235 inch. Operating Temperature Range: -20’C to +75’C. Model Number – 7881A, Belden Inc. For underground application, cable shall be wet location rated.
3. NEC/UL specification CMR, UL444, UL verified category 6.
4. Manufacturer:
   a. Belden Inc.
   b. Or approved equal.

2.03 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE for No.6 and larger, other use THHN/THWN, insulation.

B. Direct Buried: 4/0 Bare tinned stranded copper, unless otherwise noted on drawings.

2.04 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arcs and Fireproofing:
   a. 30-mil, elastomer
   b. Manufacturers and Products:
      1) Scotch; Brand 77, with Scotch Brand 69 glass cloth tape binder.

2) Plymount; Plyarc 30, with Plymount Plyglas glass cloth tape binder.
3) Or approved equal.

B. Identification Devices:
1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings.
2. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
3. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:
1. Nylon, Self-Insulated Crimp Connectors:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulink.
3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulink.
3) ILSCO.

D. Cable Lugs:
1. In accordance with NEMA CC I.
2. Rated 600 volts of same material as conductor metal.
3. Insulated, Locking-Fork, Compression Lugs:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) ILSCO; ILSCONS.
3) Or approved equal.
4. Un-insulated Crimp Connectors and Terminators:
a. Manufacturers and Products:
1) Square D; Versitide.
2) Thomas & Betts; Color-Keyed.
3) ILSCO.
5. Un-insulated, Bolted, Two-Way Connectors and Terminators:
a. Manufacturers and Products:
1) Thomas & Betts; Locktite.
2) Burndy; Quiklug.
3) ILSCO.

E. Cable Ties: Nylon, adjustable, self-locking, and reusable.
1. Manufacturers and Product: Thomas & Betts; TY-RAP or approved equal.

F. Heat Shrinkable Insulation: Thermally stabilized, crosslinked polyofin.
1. Manufacturers and Product: Thomas & Betts; SHRINK-KON or approved equal.

2.05 PULLING COMPOUND

A. Nontoxic, non-corrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

D. Manufacturers and Products:
   1. Ideal Co.; Yellow 77.
   2. Polywater, Inc.
   3. Cable Grip Co.

2. 06 WARNING TAPE

A. As specified in Section 16110, RACEWAYS.

2.07 SOURCE QUALITY CONTROL

A. Conductors 600-Volts and Below: Test in accordance with UL 44 and 854 Standards.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation to be in accordance with NECA 5055.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.

E. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

F. Bundling: Where single conductors and cables in manholes, hand holes, vaults, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

G. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

H. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

I. Cable Tray Installation:
1. Install wire and cable parallel and straight in tray.
2. Bundle, in groups, all wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
3. Clamp cable bundles prior to making end termination connections.
4. Separate cables of different voltage rating in same cable tray with barriers.
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   a. Horizontal Runs: 20 feet.
   b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:
1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide.
2. No. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	Gray Brown Orange Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation. Coordinate with AHJ and local codes and adjust the color accordingly.		

4. Tracer: Outer covering of white with an identifiable colored strip other than green in accordance with NFPA 70.

B. Conductors Above 600 Volts: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide.
   1. Colors:
      a. Grounded Neutral: White.
      b. Phase A: Brown.
      c. Phase B: Orange.
      d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

A. Circuits Appearing in Circuit Schedules: identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, hand holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Not Appearing in Circuit Schedules:
   1. Assign circuit name based on device or equipment at load end of circuit.
   2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

C. Method:
   1. Conductors No. 3 AWG and Smaller: Identify with sleeves.
   2. Cables, and Conductors No. 2 AWG and Larger:
      a. Identify with marker plates.
      b. Attach marker plates with nylon tie cord.
   3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice unless specifically indicated or approved by ENGINEER and Owner/Plant Superintendent.

C. Connections and Terminations:
   1. Install wire nuts only on solid or stranded conductors.
   2. Install nylon self-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 6 AWG and smaller.
   3. Install un-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
   4. Install un-insulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
   5. Install un-insulated bolted, two-way connectors for motor circuit conductors No. 12 and larger.
   6. Tape insulates all un-insulated connections.
   7. Place no more than one conductor in any single-barrel pressure connection.
   8. Install crimp connectors with tools approved by connector manufacturer.
   9. Install terminals and connectors acceptable for type of material used.

10. Compression Lugs
    a. Attach with a tool specifically designed for purpose.
    b. Tool shall provide complete controlled crimp and shall not release until crimp is complete.
    c. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Terminations:
    1. Indoors: Use general purpose, flame retardant tape.
    2. Outdoors: Use flame retardant, cold- and weather-resistant tape.

F. Cap spare conductors and conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:
    1. Remove surplus wire, bridle and secure.
    2. Where conductors pass through openings or over edges in sheet metal, remove bums, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:
    1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
    2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
    3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
    4. Where connections of cables installed under this section are to be made under Section 17000, INSTRUMENTATION AND CONTROL, leave pigtails of adequate length for bundled connections.
    5. Cable Protection:
        a. Under Infinite Access Floors: May be installed without bundling.
        b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2-inch in diameter.
        c. Maintain integrity of shielding of instrumentation cables.
        d. Ensure grounds do not occur because of damage to jacket over the shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as required.

B. Warning Tape: Install approximately 12 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

3.06 FIELD QUALTTY CONTROL

A. In accordance Section 16950, ELECTRICAL TESTING.

END OF SECTION

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SECTION 16405

ELECTRIC MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. Anti-Friction Bearing Manufacturers' Association (AFBMA):
    a. 9, Load Ratings and Fatigue Life for Ball Bearings.
    b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American National Standards Institute (ANSI): C50.41, Polyphase Induction Motors for Power Generating Stations.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    a. 85, Test Procedure for Airborne Sound Measurements on Rotating Machines.
    b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
    c. 114, Standard Test Procedures for Single-Phase Induction Motors.
    d. 620, Guide for Construction and Interpretation of Thermal Limit Curves for Squirrel-Cage Motors Over 500 Horsepower.
    e. 841, Recommended Practice for Chemical Industry Severe-Duty Squirrel-Cage Induction Motors, 600V and Below.
4. National Electrical Manufacturers Association (NEMA):
    a. MG 1, Motors and Generators.
    b. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
    c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
5. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
6. Underwriters Laboratories (UL):
    a. 547, Thermal Protectors for Electric Motors.
    b. 674, Electric Motors and Generators Used in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. ODP: Open drip-proof enclosure.

E. TEFC: Totally enclosed, fan cooled enclosure.

F. TENV: Totally enclosed, non-ventilated enclosure.

G. WPI: Open weather protected enclosure, Type I.

H. WPII: Open weather protected enclosure, Type II.

I. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

1.04 SUBMITTALS

A. Shop Drawings:
1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
   a. Service factor.
   b. Locked rotor current.
   c. No load current.
   d. Safe stall time for motors 200 horsepower and larger.
   e. Multispeed load classification (e.g., variable torque).
   f. Adjustable frequency drive motor load classification (e.g., variable torque) and minimum allowable motor speed for that load classification.
4. Enclosure type and mounting (e.g. horizontal, vertical).
5. Dimensions and total weight.
6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
9. Bearing life.
10. Space heater voltage and watts.
11. Description and rating of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture-sensing system.

B. Quality Control Submittals:

1. Factory test reports, certified.
2. Manufacturer's Certificate of Proper Installation, 100 horsepower and larger.
3. Operation and Maintenance Manual.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. General Electric Water.

B. Reliance.

C. Teco-Westinghouse.

D. U.S.Motors.

E. Or approved equal.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:
1. Maximum ambient temperature not greater than 50 degrees C.
2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency, Adjustable Speed Applications: Driven equipment brake horsepower at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

2.04 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3
450 hp and larger	4,000	3

C. Suitable for full voltage starting.

D. One hundred horsepower and larger also suitable for reduced voltage starting with 65 or 80 percent voltage tap settings on reduced inrush motor starters.

E. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

F. Motor for Variable Frequency Drive (VFD) shall meet the requirement of this specification section 2.16.B.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 horsepower, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:
   1. Efficiency:
      a. Tested in accordance with NEMA MG 1, paragraph 12.54.1. All motors shall be premium efficiency.
      b. Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.
   2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 15 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: Sealed windings in accordance with NEMA MG 1.

C. Three-Phase and Integral Horsepower Motors, Unless Otherwise Indicated in Motor-Driven Equipment Specifications: Class F with Class B rise at nameplate horsepower and designated operating conditions, except EXP and DIP motors which must be Class B with Class B rise. Insulation shall be chemical and humidity resistant.

2.09 ENCLOSURES

A. All enclosures to conform to NEMA MG 1.

B. Unless otherwise noted, all motors shall be TEFC and shall be furnished with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):
1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group C and D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
4. Thermostat leads to terminate in a terminal box separate from main terminal box.

D. Dust-Ignition-Proof (DIP):
1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class II, Division 1, Group E, F, G.
2. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
3. Thermostat leads to terminate in a terminal box separate from main terminal box.

E. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Paragraph SPECIAL MOTORS.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1-11.06 and 20.62 and NFPA 70, Article 430:

Voltage	Horsepower	Percentage
Below 600	15 thru 125	500
Below 600	150 thru 300	275
Below 600	350 thru 600	225
Above 600	All Sizes	200

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:
1. 3/4 horsepower and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.

2. 1 Through 400 horsepower: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Above 400 horsepower: Regreasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
4. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in AFBMA 9 and 11.

B. Vertical Motors:
1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer's standard lubrication 100 horsepower and smaller.
   c. Oil lubricated 125 horsepower and larger.
   d. Minimum 100,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer's standard bearing type.
   b. Manufacturer's standard lubrication 100 horsepower and smaller.
   c. Oil lubricated 125 horsepower and larger.
   d. Minimum 100,000 hours L-1O bearing life.

C. Regreasable Antifriction Bearings:
1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:
1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1 and be less than levels in 12.53.3 at no load.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1-12.06 and 1-12.07.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard. Field painting in accordance with Section 09910, PAINTING AND PROTECTIVE COATINGS.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for Guarded Machine in NEMA MG 1.

B. Winding Thermal Protection:

1. Thermostats:
   a. Motors for constant speed and adjustable speed application 50 and larger.
   b. Bi-metal disk or rod type thermostats embedded in stater windings (normally closed contact).
   c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Manual reset will be provided at motor controller.)
2. Motor Space Heaters: All motors 50 horsepower and larger except if otherwise noted, shall be furnished with 120V ac space heaters. The rating of the space heaters shall be determined in accordance with the motor manufacturer's standard for particular frame size and type. Coordinate the power requirements of the space heater with the manufacturer of motor starters or adjustable frequency drive for sizing of the control transformer. Space heater wire leads shall be brought out in the conduit box on the motor and clearly identified.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Motors for Variable Frequency Drives (VFD's): These motors shall be specially designed inverter duty motors and comply with NEMA MG 1.31. Motor insulation shall withstand high voltages caused by fast rise time voltage pulses associated with PWM type inverters. Motor design shall take into account motor heating caused by harmonics in the drive output. Each motor for VFD application shall have a label certifying that the motor is suitable for inverter duty. Coordinate the motor full load current data with the drive manufacturer. Inverter-duty rated motor shall be provided with AEGIS SGR split grounding ring and mounted on the motor. Select SGR split grounding ring size based on the actual shaft diameter of the motor supplied.

2.17 FACTORY TESTING

A. Tests:
1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
   a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, paragraphs 12.54 and 12.57.
   b. For motors 500 horsepower and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
4. Power factor:
   a. Speed.
   b. Current at rated horsepower.
   c. kW input at rated horsepower.
   d. On motors of 100 horsepower and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms:
    1. Routine Tests: IEEE 112, Form A-1.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16950, ELECTRICAL TESTING.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Certificate of Proper Installation.

3.04 SUPPLEMENTS

A. Table supplements, following "END OF SECTION," are a part of this Specification.

END OF SECTION

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
1	1800	80.0	81.5			Mfr.'s Std.	Mfr.'s Std.		
	1200	78.5	79.3			Mfr.'s Std.	Mfr.'s Std.		
1.5	3600	79.3	81.5			Mfr.'s Std.	Mfr.'s Std.		
	1800	79.3	82.0			Mfr.'s Std.	Mfr.'s Std.		
	1200	82.5	84.0		82.0	Mfr.'s Std.	Mfr.'s Std.		Mfr.'s Std.
2	3600	82.0	84.0			Mfr.'s Std.	Mfr.'s Std.		
	1800	81.5	83.7			Mfr.'s Std.	Mfr.'s Std.		
	1200	85.5	85.5	83.7	83.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	82.9	82.5	82.9	81.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
3	3600	82.0	84.0	82.0	82.0	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	84.8	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	87.5	88.1	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	84.1	82.9	84.1	82.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
5	3600	84.8	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	86.5	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	87.5	88.1	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	86.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
7.5	3600	86.5	88.1	84.8	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	88.5	88.5	88.4	87.5	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	86.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
10	3600	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	89.5	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
15	3600	88.5	89.8	88.4	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	91.0	91.0	90.9	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	90.2	90.2	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
20	3600	91.0	90.6	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	91.7	91.7	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.0	90.6	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
25	3600	91.7	91.0	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	92.4	92.4	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.7	91.0	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
30	3600	91.7	91.4	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	92.4	92.4	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.7	91.0	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	91.7	91.7	90.9	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
40	3600	91.7	91.7	90.2	89.3	86.6	86.1	87.0	89.0
	1800	93.6	93.0	92.8	91.7	78.2	78.2	83.0	84.5
	1200	92.4	92.4	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.0	90.9	90.2	70.0	70.5	70.0	70.5
50	3600	92.0	92.0	90.2	89.3	85.1	86.7	89.0	89.0
	1800	93.6	93.0	92.8	91.7	79.5	79.4	82.5	82.5
	1200	92.4	92.4	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.7	90.9	90.9	78.5	72.9	78.5	80.0
60	3600	92.7	93.0	91.7	90.9	85.8	88.3	87.5	89.0
	1800	93.6	94.1	93.5	92.8	80.5	79.9	80.5	80.5
	1200	93.0	93.0	92.8	91.7	81.5	81.5	81.5	81.5
	900	92.4	91.7	91.7	90.9	79.5	73.2	79.5	79.5

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
70	3600	93.6	93.6	91.7	91.7	87.1	88.5	88.5	88.5
	1800	94.5	94.5	93.5	93.5	81.0	81.5	81.0	81.5
	1200	93.6	93.5	93.5	92.8	82.0	82.0	82.0	82.0
	900	92.8	92.4	92.8	91.7	80.5	74.5	80.5	81.0
100	3600	93.6	93.3	91.7	90.7	87.0	88.2	87.0	88.5
	1800	95.1	94.5	94.0	93.5	81.0	81.0	81.0	81.0
	1200	93.6	93.6	92.8	92.8	82.1	81.7	85.5	85.5
	900	93.5	92.4	92.8	91.7	77.0	77.3	77.0	80.0
125	3600	93.6	93.7	91.7	91.7	86.4	89.1	87.0	90.5
	1800	94.5	94.7	93.5	92.8	85.4	85.5	87.5	86.0
	1200	93.6	94.1	93.5	92.8	82.7	82.3	85.5	85.5
	900	93.5	93.0	92.8	92.4	78.5	78.5	78.5	78.5
150	3600	93.6	93.7	92.4	91.7	86.5	90.0	86.5	90.5
	1800	95.0	95.2	94.5	94.0	82.5	85.0	84.5	85.0
	1200	94.5	94.5	93.5	94.0	81.5	81.5	81.5	81.5
	900	93.5	93.0	92.8	92.4	78.0	78.5	78.0	78.5
200	3600	94.3	94.3	92.4	93.0	87.8	89.4	91.0	91.0
	1800	95.0	95.2	94.0	94.0	85.2	86.5	87.0	87.0
	1200	94.5	94.5	93.5	93.5	79.0	82.5	79.0	82.5
250	3600	94.3	94.7	91.7	92.4	85.0	86.5	85.0	96.5
	1800	85.4	95.4	94.5	94.5	79.0	79.0	79.0	79.0
	1200	95.0	94.5	94.5	93.5	82.0	82.0	82.0	82.0
300	3600	93.7	94.3			89.8	89.9		
	1800	95.4	95.2	94.5	94.0	80.0	80.0	800	80.0
	1200	93.7	93.7			84.5	90.1		
350	3600	94.3	94.7			89.4	85.9		
	1800	94.7	94.7			85.9	85.9		

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
400	3600	94.3				88.4			
	1800	9437				86.8			
450	3600	94.7				89.1			
500	3600	94.7				88.3			

SECTION 16450

GROUNDING

PART 1 GENERAL

1.01 SCOPE

A. Provide and install grounding system as shown on drawings and as specifies herein complete in place.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American National Standards Institute (ANSI): C2, National Electrical Safety Code (NESC).
   2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

B. Submittals
   1. Shop Drawings:
      a. Product Data:
         1) Exothermic weld connectors.
         2) Mechanical connectors.
         3) Compression connectors.
         4) Ground rods.
         5) Ground conductors (if not submitted with 16120),
         6) Grounding wells, etc. as needed for grounding system.

C. UL Compliance
   1. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper clad.

B. Diameter: Minimum 5/8 inch.

C. Length: 20 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 16120, CONDUCTORS.

2.03 CONNECTORS

A. Exothermic Weld Type:
   1. Outdoor Weld: Suitable for exposure to elements or direct burial.
   2. Indoor Weld: Use low-smoke, low-emission process.

3. Manufacturers:
   a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
   b. Thermoweld.
   c. Or approved equal.

B. Compression Type:
   1. Compress deforming type; wrought copper extrusion material.
   2. Single indentation for conductors 6 AWG and smaller.
   3. Double indentation with extended barrel for conductors 4 AWG and larger.
   4. Barrels pre-filled with oxide inhibiting and anti-seizing compound and sealed.
   5. Manufacturers:
      a. Burndy Corp.
      b. Thomas and Betts Co.
      c. Ilso Corp.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.
   1. Manufacturers:
      a. Burndy Corp.
      b. Thomas and Betts Co.
      c. Ilso Corp.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers:
   1. Christy Co.; No. G5.
   2. Lightning and Grounding Systems, Inc.; I-R Series.
   3. Or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall comply with NFPA 70 and ANSI C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed non-current-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. Shielded Control Cables:
   1. Ground shield to ground bus at power supply for analog signal.
   2. Expose shield minimum I inch at termination to field instrument and apply heat shrink tube.
   3. Do not ground control cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment-grounding conductor connected at both ends to non-current carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment-grounding conductor connected at both ends to non-current carrying grounding bus.

C. Motors Less Than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

3.05 GROUNDING WELLS

A. Install inside buildings, asphalt, and paved areas.

B. Install riser ring and cover flush with surface.

C. Place 9 inches crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:
   1. Above grade Connections: Use exothermic weld, mechanical, or compression-type connectors. Material as listed in part 2.
   2. Below grade Connections: Install exothermic weld type connectors.
   3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
   4. Notify Engineer before backfilling ground connections.

B. Exothermic Weld Type:
   1. Wire brush or file contact point to bare metal surface.
   2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
   3. Avoid using badly worn molds.
   4. Mold to be completely filled with metal when making welds.
   5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:
   1. Install in accordance with connector manufacturer's recommendations.
   2. Install connectors of proper size for grounding conductors and ground rods specified.
   3. Install using connector manufacturer's compression tool having proper sized dies and proof of calibration within the last 12 months.

D. Mechanical Type:
   1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
   2. Install in accordance with connector manufacturer's recommendations.
   3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each.

B. Ground Rod Floor Protrusion: 4 to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all non current-carrying metal parts, and any metallic raceway grounding bushings to ground rod with No. 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

3.11 INSTRUMENT GROUND - SURGE SUPPRESSION

A. Connect all instrument surge protection with #6 insulated copper groundwire (in conduit where above grade) to closest plant ground system

3.12 BONDING

A. Bond to Main Conductor System:

B. All roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.

C. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.

D. Provide air terminals as required.

E. Bond steel columns or major framing members to grounding system per National Electrical Code.

F. Bond each main down conductor to grounding system.

G. All conduits terminations in panels shall be grounded using appropriate ground bushing and conductor to nearest ground point.

3.13 GROUNDING SYSTEM

A. Grounding Conductor, per section 16120:
   1. Completely encircle building structure.
   2. Bury minimum 30” below finished grade.
   3. Minimum 2 feet distance from foundation walls.

B. Interconnect ground rods by direct-buried copper cables.

C. Connections:
   1. Install ground cables continuous between connections.
   2. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and non-accessible connections.
   3. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
   4. Use bolded offset parapet bases or through-roof concealed base assemblies for air terminal connections.
   5. Provide interconnections with electrical and telephone systems and all underground water and metal pipes.
   6. Provide electric service arrestor ground wire to building water main.

3.14 FIELD QUALITY CONTROL

A. As specified in Section 16950, ELECTRICAL TESTING.

END OF SECTION

SECTION 16480

LOW VOLTAGE MOTOR CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. American National Standard Institute (ANSI):
   a. C2, National Electrical Safety Code (NESC).
   b. C57.12.28, Switchgear and Transformers - Pad-Mounted Equipment- Enclosure Integrity.
   c. Z55, Gray Finishes for Industrial Apparatus and Equipment.
2. National Electrical Manufacturers Association (NEMA):
   a. AB 1 Molded Case Circuit Breakers.
   b. ICS 1, General Standards for Industrial Control and Systems.
   c. ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies.
   d. ICS 2.3, Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers
   e. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   f. 250-1997, Enclosures for Electrical Equipment (1,000 volts maximum).
3. National Fire Protection Association (NFPA): 70-90, National Electrical Code. (NEC) Latest Edition.
4. Underwriters Laboratories, Inc. (UL):
   a. 98, Standard for Safety Enclosed and Dead-Front Switches, Eleventh Edition.
   b. 489, Standard for Safety Molded Case Circuit Breakers and Circuit Breaker Enclosures, Seventh Edition.
   c. 845, Standard for Safety Motor Control Centers, Third Edition.
   d. 508A Industrial Control Equipment.
5. Uniform Building Code (UBC): Section 2312, Earthquake Requirements.
6. InterNational Electrical Testing Association (NETA) Acceptance Testing Specifications, latest edition.
7. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, latest revision, Standard Test Procedure for Polyphase Induction Motors and Generators
   b. 43, latest edition, Recommended Practice for Testing Insulation Resistance of Rotating Machinery

1.02 SUBMITTALS

A. Shop Drawings:
1. Itemized bill of material.
2. Descriptive information.
3. Dimensional drawings.
4. Conduit entrance locations/provisions.
5. Bus data including horizontal and vertical bus capacities, voltage rating and interrupting capacity. Include materials of construction

6. Protective Devices: Copies of time-current characteristics.
7. Anchoring instructions and details.
8. Typed tabulation:
   a. Motor name; tag (equipment) numbers as shown on Drawings.
   b. Motor horsepower.
   c. Nameplate full load current.
   d. Measured load current and voltage.
   e. Heater catalog number.
   f. Protective device trip settings.
9. Attach above typed, tabulated data to a copy of starter manufacturer's overload heater selection tables for the starters provided.
10. Control Diagrams:
    a. NEMA ICS 2, Section 322.08 Type I.
    b. Wiring Type B.
    c. In addition to standard NEMA control diagrams, provide the following:
       1) Remote control devices.
       2) Remote indication and/or pilot lights.
       3) Interconnections and interlocking circuits between starter and remote equipment.
       4) Remote sensors.
       5) Tag numbers associated with all control devices and equipment.
       6) Clearly identify items provided by others.
11. One-line diagrams.
12. Schematic (elementary) diagrams. Custom schematics shall be furnished. Diagrams shall include all remote devices. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the Contractor stamped "REJECTED-RESUBMIT".
13. Outline diagrams.
14. Interconnection diagrams.
15. Enclosure NEMA rating and color.
16. Ground bus size and material of construction.
17. Main incoming line entry provision (top or bottom).
18. Control unit nameplate schedule.
19. All circuit breaker types, frames and settings.
20. All starter NEMA sizes, auxiliary contact provisions, coil voltage Relays, timers, pilot devices, control transformer VA and fuse sizes.
21. Short circuit rating of the complete assembly.
22. Replacement parts lists and operation and maintenance procedures.
23. Plan and elevation dimensional views of each MCC section.

B. Quality Control Submittals:
   1. Manufacturer's installation instructions.
   2. Operation and Maintenance Manual.
   3. Factory test reports, certified.

1.03 UL COMPLIANCE

A. Products manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing Mark. Where shown or required motor control centers shall be suitable for service entrance.

1.04 PACKING AND SHIPPING

A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within the building.

1.05 RESPONSIBILTIES:

A. The information provided on the drawings is for guidance only and does not limit the equipment size. When motors furnished differ from the expected rating indicated the Contractor shall make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate the motors actually installed.

1.06 INSPECTION COORDINATION:

A. The Contractor shall provide access to the WORK for the Engineer as requested for inspection. The Contractor shall provide 48 hours notice of its intention to begin new WORK activities.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Square D.

B. Eaton (Cutler-Hammer).

C. General Electric.

D. Allen-Bradley

E. Or approved equal.

2.02 MOTOR CONTROL

A. General:
   1. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, (class A), the NEC, and UL.
   2. Like Items of Equipment: Same manufacturer as low voltage switchboard and panelboards for standardization. Devices of the same type shall be products of the same manufacturer. This requirement applies to all control devices, and insofar as practical, to equipment manufactured on a production basis. It also applies without exception to equipment custom fabricated for this project.
   3. Make adjustments as necessary to wiring, conduit; disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

4. Overload Protection:
    a. Each motor shall have a direct current sensing solid-state overload protection in all ungrounded phases. This protection shall have current overload relays sensitive to motor current, and mounted within the motor controller. Reset of the protection shall be manually activated with externally operated reset button. All overload protection devices shall be the inverse time limit type and match the motor characteristic.

5. Control Transformer:
    a. Two winding, 120-volt secondary, primary voltage to suit.
    b. Two current-limiting fuses for primary circuit.
    c. One fuse in secondary circuit.
    d. Mount within starter unit.
6. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
7. Lifting lugs on all equipment and devices weighing over 100 pounds.
8. Anchor Bolts: Galvanized, sized by equipment manufacturer, and as specified in Section 05500, METAL FABRICATIONS AND CASTINGS.
9. Operating Conditions:
    a. Ambient Temperature: Maximum 40 degrees C.
    b. Equipment to be fully rated without any derating for operating conditions listed above.
10. Enclosures: In accordance with NEMA 250 and ANSI C57.12.28.
11. Equipment Finish:
    a. Electro-coating process applied over a rust-inhibiting phosphated base coating.
    b. Exterior Color: Manufacturer's standard.
12. All manual starters and combination motor starters shall be lockable in the off position.

B. Manually Operated Starter, Fractional Horsepower:
1. Rating: 16 amperes continuous at 277 volts maximum.
2. Single-phase, non-reversing, full voltage with overload protection.
3. Toggle operated, keyed where shown.
4. Enclosure: NEMA 250, Type 4, unless shown otherwise.
5. Neon Light: Red.
6. Handle guard/lock-off attachment.

C. Manually Operated Starter, Integral Horsepower:
1. Rating: Horsepower rated to maximum of 10 horsepower at 600 volts with overload protection.
2. Single or three-phase, non-reversing, full voltage.
3. Control: Toggle or pushbutton.
4. Enclosure: NEMA 250, Type 4, unless shown otherwise.
5. Red pilot light in series with an auxiliary contact.
6. Locking in OFF position.
7. Two spare auxiliary, field-convertible contacts.

D. Combination Full-Voltage, Magnetic Starter:
1. Rating: Horsepower rated at 600 volts, UL labeled for 100,000 amperes with overload protection.
2. Three-phase, non-reversing, full voltage.

3. Control: As shown.
4. Disconnect Type: Motor circuit protector.
5. Enclosure: As shown.
6. Pilot Lights: As shown.
7. Pad-lockable operating handles.

E. Solid State Reduced Voltage Starter: Not used.

2.03 MOTOR CONTROL CENTERS

A. General:
   1. In accordance with NEMA ICS 2 and UL 845.
   2. The motor control centers shall be 600-volt class suitable for operation on a three-phase, 60-Hz system. The system operating voltage and number of wires shall be as indicated, on project drawings.
   3. MCC designated as service entrance rated shall include provision for termination of an incoming neutral conductor in conformance to NEC requirements.
   4. Short Circuit Rating: Amperes rms symmetrical as shown on Drawings for entire motor control center as a complete assembly.
   5. All controllers, main and branch circuit breakers, wire connections, and other devices to be front mounted and accessible unless otherwise noted.
   6. NEMA ICS 2, Section 322.08.
      a. Class: IIS.
      b. Type: B. Diagrams and wiring.
      c. Provide blank spaces on interconnection diagrams to add control conductor code designations during installation of equipment.
   7. Size and Arrangement
      a. Motor control centers shall be of mechanical groupings of control center units, assembled into a lineup of control center sections. Each control section shall be nominally 90-inches tall by minimum 20-inches deep.
      b. MCC's shall be designed to not exceed the space requirements as indicated on the Contract Drawings, including spaces, spares, and future compartments. MCC's shall be subject to rejection for exceeding the lengths indicated where allotted space is critical.
      c. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing the MCC provides the spares, space, and future provisions indicated.
      d. All switches and circuit breakers used as switches shall be located so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6-feet 7-in.

B. Enclosure:
   1. Type: NEMA 250, Type 1, gasketed.
   2. Construction:
      a. Sheet steel reinforced with channel or angle irons.
      b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
      c. Removable top cover plates and bottom cover plates.

d. Removable plates on end panels for future bus extension.
e. Structural members shall be fabricated of not less than 12 gauge steel and side and top panels and doors shall be not less than 14 gauge steel.

4. Section Mounting: Removable formed-steel channel sills and lifting angles.
5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
6. Vertical Wiring Compartment: Full height, isolated from unit starters with separate door.
7. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
8. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
9. Door Interlocking: Interlock starter and feeder doors mechanically so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access at any time.
10. External disconnect handles, pad-lockable in OFF position.
11. Cable Entrance: Main leads enter as shown on the Drawings. Control and feeder circuits enter from top and bottom.
12. Spaces designated as "SPACE" or "BLANK" shall include blank hinged doors and vertical bus bars.
13. Control units inside compartments shall be clearly identified with tags or stencil markings.
14. Each control unit including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate. Identification shall include circuit number as indicated.
15. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.
16. Where "L" or "U" shaped MCC layouts are indicated, corner compartments shall have similar current and short circuit ratings as functional compartments.
17. Fans, heat exchangers, transformers, capacitors, junction boxes, or other devices may not be mounted on the outside of the motor control center enclosure.
18. Finish for motor control center shall be light grey, ANSI 61. The panels shall be given 2 coats of primer inside and out and 2 coats of enamel finish. External colors other than ANSI 61 will not be acceptable.
19. Each section shall be dead-front and dead-back construction. Rear access shall not be necessary for inspection and maintenance. The structure arrangement shall be for front only mounting of units.
20. Power cables to the motor control center shall be either top or bottom feed as indicated on the project drawings. Provide all necessary lugs, clamps, and supports to terminate incoming power cables.

C. Bus:
1. Horizontal Power Bus:
a. Three-phase tin-plated, copper, entire width of control center, rated as indicated.

b. Silver-plated at joints.
c. Construct to allow future extension of additional sections.
d. Pressure type solderless lugs for each incoming line cable.
e. Isolated from top horizontal wireway.
f. Provide Belleville washers on bus connection bolts.

2. Vertical Power Bus:
   a. Three-phase tin-plated, copper, full height of section, rated as required by the load but not less than 300 amperes, minimum.
   b. Silver-plated at joints.
   c. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   d. Insulated and isolated barrier complete with shutters.
   e. Provide Belleville washers on bus connection bolts.
3. Neutral Bus: None.
4. Ground Bus:
   a. Copper, tin-plated, 33 percent minimum of phase bus ampacity, entire width of control center.
   b. Provide Belleville washers on bus connection bolts.
5. Bus Bracing: 65,000 amperes rms symmetrical.

D. Motor Controller Unit:
1. Provide indicated individual components and control devices including pushbuttons, selector switches, LED indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
2. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device. Short circuit protective device shall be an instantaneous, magnetic only circuit breaker or thermal magnetic circuit breaker as defined in the project one line diagrams. All circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the open position. Reset of thermal overload elements shall be possible with unit door closed. Three phase overload trip units shall be furnished to suit the full load current of the equipment installed. Overload relays shall be solid state type capable of detecting phase loss and ground faults and shall meet NEMA class 20 tripping characteristics.

3. Magnetic starters shall have auxiliary contacts as required by electrical motor control diagrams, including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact. As a minimum, provide one normally open and one normally closed auxiliary contact.
4. Each starter unit shall have its own control power transformer. It shall have a 115-volt grounded secondary. One secondary fuse and 2 primary fuses shall be provided. Control power transformers shall be sized to accommodate the control devices indicated. Minimum transformer size is 50 VA. Local control devices shall be mounted independently of the cover door. All starters shall have a local "running" lamp and a "off" light to indicate the presence of control power when the motor is not running. Indicating lights shall be push-to-test LED type. Starters shall be provided with elapsed time meters, hand/off/auto selector switches, and other devices as indicated. All cubicle control wires shall be terminated at a pull apart disconnecting terminal block at the cubicle.

5. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers. Each control wire shall be identified at both ends. Markers shall be produced from a device specifically made to produce tags, such as manufactured by Brady Corporation or Thomas & Betts. Hand lettered markers are not acceptable.
6. Motor starters shall be designed to NEMA ratings. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be acceptable, either as part of any MCC, as remote starters, or as part of any equipment package.
7. Construction:
    a. Draw out combination type with stab connections for starters NEMA ICS, Size 4 and smaller. The fixed-type unit assembly shall be constructed so that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.
    b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 5 and larger.
    c. Readily interchangeable with starters of similar size.
    d. Pull-apart unit control wiring terminal boards on all units.

E. Starters:
1. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, Size 1.
2. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes with overload protection.
3. Three-phase, non-reversing, unless otherwise shown.
4. Disconnect Type: Motor circuit protector.
5. Combination Full Voltage, Magnetic Starter:
    a. Control: As shown.
    b. Pilot Lights: Red-ON and Green-OFF.
6. Combination Reduced Voltage Auto-Transformer Starters:
    a. Reduced voltage auto-transformer starters shall consist of a molded-case motor circuit protector in combination with a closed transition type auto-transformer starter with 50 percent, 65 percent, and 80 percent taps, and shall be set on the 65 percent tap.
    b. The starter shall have three phase solid state overload relays capable of sensing phase loss and ground fault with manual reset.
    c. The auto-transformer shall include a thermal switch wired to protect itself from overheating.
    d. Timing of the starting period shall be controlled by an adjustable accelerating relay. Requirements set forth in paragraph 2.03 for enclosures and devices apply herein.

7. Solid State Reduced Voltage Starters:
   a. Solid state reduced voltage starters shall meet the requirements of UL 508 and shall consist of an incoming power circuit breaker, a power section; logic board, isolation contactor, and paralleling full load bypass contactor.
   b. Soft Starters shall conform to the following:
      1) The SCR-based power section shall consist of 6 back-to-back SCRs, two SCRs per phase, and shall be rated for a minimum peak inverse voltage rating of 2.5 times line voltage, 1200 PIV for 480 volts. Units using triacs or SCR/diode combinations shall not be acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.
      2) Starters shall include the following logic and control functions:
         - Adjustable maximum starting current from 200 percent to 500 percent
         - Ramp time adjustment from 1 to 40 seconds
         - Adjustable linear voltage deceleration
         - Kick start
         - Phase loss protection
         - Adjustable Undervoltage/ overvoltage protection
         - Current unbalance protection
         - Instantaneous overcurrent detection.
         - Phase rotation protection (prevents starting)
         - Shorted SCR detection.
         - Selectable Class 10, 20, 30 electronic overload protection. Heat sink overtemperature protection shall be provided.
         - Dry contacts for remote indication of RUN and TRIP status
         - Battery “back up” of set starter parameters.
         - Event recorder.
         - Elapsed time meter.
         - LCD status display.
      3) The paralleling bypass contactor shall energize when the motor reaches full speed. The contactor shall be fully rated for across-the-line starting duty. The effect of the bypass contactor during normal operation is the elimination of heat buildup resulting from the voltage drop across the SCR’s. The bypass contactor may also be used as a means of starting the motor should problems be encountered with the soft starter. A door mounted selector switch shall be furnished such that the starting means can be selected as being either via the soft starter or via the bypass contactor as across-the-line.
      4) An isolation contactor shall be supplied. The isolation contactor shall remove three phase power from the input side of the solid state controller when the bypass contactor is selected for across-the-line starting.

5) The starter shall be housed in an appropriate NEMA rated enclosure as directed by project drawings. Heaters and cooling fans shall be provided if required to maintain the equipment within the manufacturer's environmental guidelines.
6) The enclosure shall be of two-door compartment type construction. The left hand compartment shall contain the starter power section and any equipment rated at line voltage. The right hand compartment shall include only that equipment rated at 120 VAC or less including the starter's CPU PC card and LCD display. The enclosure shall include a partition dividing the two compartments. Each compartment shall be designed to provide a barrier between the equipment at line voltage and the equipment at 120 VAC or less
7) The starter shall be provided with a control power transformer sized to accommodate all controls indicated on the Contract Drawings. An input power circuit breaker shall be provided. Lug termination of the incoming power conductors shall not be permitted. The starter and circuit breaker shall be rated for 65 KAIC RMS at 480V.
8) The starter shall have door mounted indication of run, phase rotation, phase loss, undervoltage, current unbalance, and current trip.
9) Door mounted LCD / keyboard display assembly designed to:
   - Set or examine operating parameters.
   - Provide starter status information.
   - Provide real-time information about line current, voltage, and frequency.
   - Provide a means to start and stop the starter

c. Pad-lockable operating handle when de-energized.
d. Unit door interlocked to prevent opening when disconnect is in closed position.
e. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
f. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

8. Two Speed Starters:
   a. Two Speed Starters shall be of the two-winding type unless otherwise indicated.
   b. Requirements set forth in paragraph 2.03 for enclosures and devices apply herein.
9. Disconnecting Device:
   a. In each starter, control circuit disconnect to de-energize circuits in unit which are not de-energized by starter power disconnect device.
   b. Pad-lockable in OPEN position.
10. Circuit Breaker:
   a. Meeting the requirements of NEMA AB1 and UL 489.
   b. Molded case with manufacturer's recommended trip setting for maximum motor protection.

c. Magnetic trip only.
d. Tripping indicated by operating-handle position.
e. Interrupting capacity required for connection to system with short circuit capacity indicated.

11. Fused Switch:
    a. Heavy-duty, motor rated load-break, quick-make, quick-break type meeting the requirements of UL 98 and NEMA KS 1.
    b. Current-limiting fuses, with rejection clips.
12. Load Detector Relay:
    a. Manual reset with adjustable differential.
    b. Manufacturer:
        1) Cutler-Hammer; Type D60LA.
        2) Allen-Bradley; Bulletin 2100.
        3) Or approved equal.
13. Motor Overload Protection:
    a. Direct current sensing solid-state overload protection in all ungrounded phases.
    b. Manual-reset overload relays.
14. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.
15. Ground Fault Protection: Where indicated and as specified in paragraph Feeder Units and Main Protective Device, except provide instantaneous operation device.
16. Capacitor Connection: Terminals to allow easy connection of power factor correction capacitors on source side of starter overload relays on starters where capacitor connection is shown.

E. Control Unit:
1. Disconnecting Device: Capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated and as specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
3. Control Wiring:
    a. Minimum wire size 14 AWG copper.
    b. Permanent sleeve type markers with wire numbers applied to each end of wires.
    c. Terminate wires using insulated locking fork or ring type crimp terminals.
    d. Terminate current transformer leads on shorting type terminal blocks.

F. Incoming Line Terminal:
1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable entering section as shown.
3. Maximum short-circuit rating of 65,000 amperes.
4. Mechanical type CU-/AL lugs for 75 degrees C cable.

G. Feeder Unit and Main Protective Device:
1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable entering section as shown.
3. Molded Case Circuit Breaker:
    a. In accordance with NEMA AB 1 and UL 489.

b. Main and feeder protective device.
c. UL labeled as suitable for service entrance.
d. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
e. Indicate tripping by operating-handle position.
f. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
g. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.
h. Circuit breakers with a frame size of 225 amperes to 1,200 amperes shall be molded case with interchangeable thermal and adjustable magnetic trip or RMS sensing electronic trip elements.
i. The interrupting capacity of all main, and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes. Service disconnects rated 1000A or more shall provide ground fault protection of equipment.

4. Ground Fault Protection:
   a. Suitable for 480-volt, three-phase, three-wire, solidly grounded wye system.
   b. Ground sensors to encircle all phase conductors and neutral conductor where used and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
   c. Circuit breaker shunt trip and relay operating from fused 120-volt ac control source within control center.
   d. Manufacturers:
      1) Ground Fault System ITE; Ground Shield.
      2) General Electric; Ground Break.
      3) Or approved equal.
5. Phase Monitoring Relay:
   a. Three-phase monitoring relay to protect against low voltage, voltage unbalance, and phase reversal.
   b. Manufacturer: Furnas; Class 47 or approved equal.

H. Instruments:
1. Provide solid state type metering where indicated. Include CT's and PT's of ratios as indicated.
   a. Solid state “metering” shall include but not be limited to the following functions:
      1) Metering: Device shall monitor Voltage (VLL/VLN), Current (Amps per phase), Real Power (W), Reactive Power (VAR) and Apparent Power (VA). Device shall have data gathering ability for analysis. The device(s) shall conform to the requirements of UL 508.

2) Alarms: Device shall utilize assignable output relays to trigger alarms for specific applications. Alarm messages shall be displayed on the front panel of the device. Alarm outputs via dry contacts shall alarm Over/Under Current, Over/Under Voltage, Current Unbalance/Neutral Current, Phase Sequence, Over/Under Frequency, Power Factor and Switch Inputs.

3) Communications: Device shall be able to communicate with current and future process control systems using standard protocols such as Devicenet, Ethernet, Modbus, Profibus, or as called for on project drawings. Front and rear panel communications ports shall be available for information access. Display of monitored values shall be available both locally and remotely.

I. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30 mm. Miniature style devices are not acceptable. All devices shall conform to the requirements of UL 508.
1. Lens colors for “run”, “stop”, “on”, “off”, “open”, and “closed” shall be coordinated with the District’s requirements.
2. Pilot lights shall be LED, push-to-test type.
3. Provide hazardous location type pilot devices in classified locations per the NEC.

J. Elapsed Time Meters: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

K. Time Delay Relays: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

L. Relays shall be 3 PDT with 10 amp contacts, plug-in type utilizing rectangular blades and provided with sockets for screw-type termination and hold-down clips.

M. Reset Timers: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

N. Nameplates:
1. Laminated plastic; white, engraved to black core.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.
4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel pan head screws on face of control center.

O. Factory Testing: NEMA ICS 1, Section 109.

2.04 SPARE PARTS

A. The Contractor shall furnish the following for each MCC as a minimum:
1. Three bezels of each color installed for pilot indicators
2. One dozen panel lamps
3. One dozen control fuses of each size installed

B. Spare parts shall be identified by MCC number, type, size, and manufacturer

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with NEMA ICS 2.3, Submittal Drawings, and Manufacturer's Instructions and Recommendations.

B. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

E. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.

F. Motor control centers shall be installed on 3-1/2-inch concrete pads. After leveling and shimming, the Contractor shall anchor motor control centers to concrete pads, and shall grout so that no space exists between the pad and support beams.

G. The Contractor shall:
1. Torque all bus bar bolts to manufacturer's recommendations. Tighten all sheet metal and structure assembly bolts.

2. Adjust all Motor Circuit Protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor. Verify that overload devices are proper for equipment installed; make necessary changes in overload devices as required for motors having power factor correcting capacitors.
3. After equipment is installed, touch up scratches and verify that nameplate, and other identification is accurate.
4. Provide high voltage switchboard matting in front of the MCC. The mat shall be 1/4-inch thick and 36-inches wide.

3.02 TESTING

A. Factory Test: All motor control centers, micro processor based soft starters and their components shall be given manufacturer's standard electrical and mechanical production tests and inspections. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of all components including controls, protective devices, metering, and alarm devices.

B. Field Test MCC:
1. Visual and mechanical inspection after installation
    a. Inspect for physical damage, proper anchorage, and grounding
    b. Verify that the ratings of the solid state overload relays match the motor full-load current nameplate data.

c. Check tightness of bolted connections.

C. Electrical Tests
1. Insulation tests
a. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute. Test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.
b. Measure insulation resistance of each starter section phase to phase and phase to ground with the starter contacts closed and the protective device open. Test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.
c. Measure insulation resistance of each control circuit with respect to ground
2. Verify proper operation of control logic in all modes of control.

3.03 CIRCUIT BREAKERS

A. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.

B. Adjust to approximately II times motor rated current.

C. Determine motor rated current from motor nameplate following installation.

3.04 OVERLOAD RELAY

A. Adjust overload relays after the actual nameplate full-load current rating of motor has been determined.

3.05 MOTOR DATA

A. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
1. Motor served by tag number and equipment name.
2. Nameplate horsepower.
3. Motor code letter.
4. Full load amperes.
5. Service factor.
6. Installed overload relay heater catalog number.

3.06 FIELD QUALITY CONTROL

A. In accordance with Section 16950, ELECTRICAL TESTING.

3.07 MANUFACTURERS' SERVICES

A. Furnish manufacturer's representative in accordance with Section 01640, MANUFACTURERS' SERVICES, for the following services at jobsite or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
1. 1 person-day for installation assistance, and inspection of installation.

2. 1 person-day for functional and performance testing.
3. 1 person-day for plant startup.

END OF SECTION

SECTION 16485

VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Provide all labor, materials, equipment and incidentals required, and install, place in operation and field test variable frequency drive(s) (VFD's).

B. The variable frequency drive shall be a space vector Pulse-Width Modulated (PWM) design. Modulation methods which incorporate "gear-changing" techniques are not acceptable. The final responsibility of distributor or packager modifications to a third-party standard product will reside with the VFD manufacturer. The VFD manufacturer shall have overall responsibility for the drives. All drives shall be supplied by one manufacturer. The VFD shall be manufactured within the United States of America to alleviate concerns of future serviceability and parts availability.

C. VFD's shall be 18 pulse drives with output filter for motor 150HP and above. VFD's for below 150HP and above 30HP shall be 6-pulse drives with 5% input line reactor and output filter. VFD's for 30HP and below shall be 6-pulse drives with 3% input line reactor and output filter. External phase shifting transformers will not be accepted.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Pumps, General

B. Division 11 - Equipment

C. Section 16405 - Electric Motors

D. Division 17 – Instrumentation and Controls

1.03 QUALITY ASSURANCE

A. The entire VFD system as described in section 2.01B shall be factory assembled and system tested by the VFD manufacturer to assure a properly coordinated system.

B. Codes: Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:
1. Local Laws and Ordinances.
2. State and Federal Laws.
3. National Electric Code (NEC).
4. Underwriters Laboratories (UL).
5. American National Standards Institute (ANSI).
6. National Electrical Manufacturers Association (NEMA).
7. Institute of Electrical and Electronics Engineers (IEEE).

C. The complete drive system shall be UL listed.

D. Acceptable Manufacturers:
1. ABB.
2. Square D.
3. Eaton (Cutler-Hammer)
4. Or Owner/Engineer approved equal.

1.04 SUBMITTALS

A. Submittals shall conform in all respects to Section 01330.

B. Submittals shall be custom prepared by the VFD manufacturer for this specific application.

C. Submittal information shall include, but not be limited to:
1. Equipment dimensions, including stub-up locations, shipping splits and shipping weights.
2. Catalog cuts of major components.
3. Spare parts list, per Paragraph 3.03.
4. Certifications, including:
   a. Warranty, per section 1.05.
   b. Efficiencies, per section 2.02.A.1.

1.05 WARRANTY

A. All equipment furnished under this section shall be warranted for on site parts and labor by the contractor and the equipment manufacturers for a period of five years after successful completion of VFD system startup and acceptance. The warranty shall cover all Drive failures including line anomalies – including lightning strikes, load anomalies, accidental exposure to moisture or corrosives and accidental collision of other physical damage; product misapplications, vandalism and chronic problems due to the misapplication are not covered. The cost of the warranty shall be included in the bid.

PART 2 PRODUCTS

2.01 MATERIAL AND EQUIPMENT

A. Any modifications to a standard product required to meet this specification shall be performed by the VFD manufacturer only. Distributor or system integrator changes to the VFD manufacturer's product are specifically disallowed.

B. The VFD system shall consist of an input line reactor, 6 pulse converter section, output inverter and control logic section, and output filter.

C. Input circuit breaker, interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power and shall be capable of being locked in the open position.

D. VFD system shall maintain a 0.95 minimum true power factor throughout the entire speed range.

2.02 VARIABLE FREQUENCY DRIVES

A. Ratings

1. The drive system shall be 96% efficient at full load and full speed and 95.5% efficient at 51% load and 80% speed. Losses to be utilized in drive system efficiency calculation shall include input transformer, harmonic filter and power factor correction if applicable, VFD converter and output filter if applicable. Auxiliary controls, such as internal VFD control boards, cooling fans or pumps, shall be included in all loss calculations. The VFD shall be heavy duty rated and shall have a rating as describes in this specification 2.02.A.2.9.
2. Rated Input Power: 460 Volts 60 Hz, +10%, -5% at rated load, 3-phase.
    a. Voltage Dip Ride-Through: VFD shall be capable of sustaining continued operation with a 40% dip in nominal line voltage. Output speed may decline only if current limit rating of VFD is exceeded.
    b. Power Loss Ride-through: VFD shall be capable of a minimum 3 cycle power loss ride-through without fault activation.
3. Output Power: As required by motors supplied. The VFD drive rating shall meet or exceed the motor horsepower rating and 110% of the motor nameplate rated full-load current.
4. Ambient Temperature Range: 0 to 40°C.
5. Elevation: Up to 3300 feet (1000 meters) above MSL without derating.
6. Atmosphere: Non-condensing relative humidity to 95%.
7. AC Line Frequency Variation: +/- 3 Hertz.
8. Power Unit Rating Basis: 110% rated current continuous, 150% rated current for one minute, at rated temperature.
9. VFD Unit Rating shall be minimum 110% of the motor full load current nameplate rating. If the 110% does not match the standard horsepower or current rating of the VFD, provide the larger size VFD unit.

B. Construction

1. The controller shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz ratio despite incoming voltage variations.
2. The controller shall have a continuous output current rating of 100% of motor nameplate current.
3. The converter section shall be 6 pulse minimum utilizing diodes.
4. The inverter output shall be generated by IGBTs. Pulse Width Modulation strategy will be of the space vector type implemented to generate a sine-coded output voltage. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. The inverters shall be able to sustain 1600 volt surges.
5. The controller(s) shall be suitable for use with any standard NEMA-B squirrel-cage induction motor(s) having a 1.15 Service Factor or with existing standard NEMA-B squirrel-cage induction motor(s) with nameplate data as shown on the plans. Provide drives with dV/dT output filters manufactured by Trans-Coil type KLC, MTE, or equal. At any time in the future, it shall be possible to substitute any standard motor (equivalent horsepower, voltage, and RPM) in the field.

6. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors. A power failure will not necessitate a reload of any drive parameter or configuration.
7. Minimum Starting Speed: When called to operate, the VFD shall immediately ramp to a minimum speed. The minimum speed shall be adjustable but initially set at 40% of maximum speed. The 4-20 MA speed signal from the PLC and potentiometer on the front of the drive shall modulate the signal between the minimum speed setpoint and the maximum output speed of the drive; i.e., at the 4 MA signal, the VFD shall run at the minimum speed. At the 20 MA signal, the VFD shall run at full speed. The potentiometer shall also adjust speed between the minimum speed setpoint and the maximum running speed. Below the minimum speed setpoint, the potentiometer shall have no effect.
8. All 6-pulse VFD’s shall be provided with 5% input line reactors.

C. Basic Features
1. The door of each power unit shall include: a keypad with a manual speed device, "LOCAL / OFF / REMOTE" mode selector switch, “VFD FAIL” light, VFD "RUNNING" light, “Motor Heater On” light, “Motor Over temperature” light, elapsed time meter, fault reset pushbutton, START and STOP pushbuttons. All lights shall be push-to-test LED type.
2. The VFD shall include a customer selectable automatic restart feature. When enabled, the VFD shall automatically attempt to restart after a trip condition resulting from instantaneous overcurrent, overvoltage, out of saturation or overload. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function (programmable for up to 3 attempts) is not successful within a customer programmable time period. Auto-Restart shall be programmable to allow for individual fault selection.
3. A door-mounted membrane keypad with integral 2-line minimum, 24-character LCD display shall be furnished, capable of controlling the VFD and setting drive parameters. The keypad shall include the following features:
   a. The digital display must present all diagnostic message and parameter values in English engineering units when accessed, without the use of codes.
   b. The digital keypad shall allow the operator to enter exact numerical settings in English engineering units. A user menu written in plain English (rather than codes) shall be provided in software in nonvolatile memory as a guide to parameter setting and resettable in the field through the keypad. Multiple levels of password security shall be available to protect drive parameters from unauthorized personnel. The drive set up parameters must be able to be transferred to new boards to reprogram spare boards.
   c. The following digital door-mounted keypad indications may be selectively displayed:
      1) Speed demand in percent.
      2) Output current in amperes.
      3) Output Frequency in hertz.
      4) Input voltage.
      5) Output voltage.
      6) Total 3-phase KW.
      7) Kilowatt hour meter
      8) Elapsed time running meter.

9) RPM.
10) DC bus voltage.

d. VFD parameters, fault log and diagnostic log shall be downloadable via the RS-232, RS-422, or RS-485 port.
e. VFD shall have hard-wired control and alarm signals as shown on Electrical Drawings.

D. Enclosure
1. Maximum enclosure dimensions for various VFD sizes shall be as follows:
a. VFD's shall be installed in the MCC line-up.

E. Protective Features and Circuits: The controller shall include the following alarms and protective features:
1. Instantaneous overcurrent and overvoltage trip.
2. Undervoltage and power loss protection.
3. Power unit overtemperature alarm and protection. Upon sensing an overtemperature condition, the VFD is to automatically trip.
4. Electronic motor inverse time overload protection.
5. Responsive action to motor winding temperature detectors or thermostatic switches. A dry contact (NC) input to the VFD is required.
6. When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed without the use of an encoder.
7. The VFD shall be protected from damage due to the following, without requiring an output contactor:
a. Three-phase short circuit on VFD output terminals.
b. Loss of input power due to opening of VFD input disconnecting device or utility power failure during VFD operation.
c. Loss of one (1) phase of input power.
8. The VFD shall continue to operate at a reduced capacity under a single-phase fault condition.
9. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:
a. Failure to connect a motor to the VFD output.
b. VFD output open circuit that may occur during operation.
c. VFD output short circuit that may occur during operation.
10. Provide input line reactors (5% impedance) when no 12 or 18 pulse transformers are supplied or required.
11. Three phase lightning and surge protection across the line input at each VFD. Lea Dynatec TVSS #GB-100, or equal.
12. Provide 120V motor heater power, if shown on drawings, that is active when the motor is off and is off when the motor is active if motor space heater is provided with the motor.

F. Parameter Settings
1. The following system configuring settings shall be provided and field adjustable, without exception, through the keypad/display unit. Except for Motor Nameplate Data, all parameters must be adjustable while the processor is on-line and the drive is running.
a. Motor Nameplate Data.
1) Motor frequency.
2) Number of poles.

3) Full load speed.
4) Motor volts.
5) Motor full load amps.
6) Motor HP.
7) Current limit, max.

b. VFD Configuration Parameters.
1) Independent accelerate/decelerate rates.
2) Max/Min speed (frequency).
3) Catch-a spinning load selection.
4) No load boost.
5) Full load boost.
6) Volts/Hertz ratio.
7) Overspeed trip.
8) Overload trip curve selection.
9) Overload trip time selection.

c. Automatic VFD Control.
1) PID utilizing an internal or external setpoint.
2) Three selectable critical speed avoidance bands with programmable bandwidths.
3) Auto start functions: On/Off, Delay On/Off. Operable from a 4-20mA signal or from the PID output, command, or feedback signal.
4) Speed Profile: Programmable entry and exit points.
5) Programmable loss of signal control: Stop, maintain last speed, or default to preselected setpoint.

2. All drive setting adjustments and operation parameters shall be stored in a parameter log which lists allowable maximum and minimum points as well as the present set values. This parameter log shall be accessible via a RS-232, RS-422, or RS-485 serial port as well as on the keypad display.
3. VFD shall have Ethernet protocol for communication. If factory default protocol is not Ethernet protocol, VFD manufacturer shall use converter to translate factory default protocol to Ethernet protocol. Using a remote I/O rack with converting hard-wired I/O points to Ethernet protocol is not acceptable.

G. Input/Output Features thru Ethernet communication. VFD shall be provided with hard-wired controls as shown on Electrical drawings as well as Ethernet communication protocol.
1. Two programmable analog inputs: – VFD speed in, spare
2. Two programmable analog outputs: – VFD speed output, spare
3. Two programmable digital inputs: – Start/Stop, spare
4. Four programmable digital outputs: – VFD fault, VFD running, VFD in remote, spare
5. One Pot input (three wire control, +10 V, wiper and common) or speed adjustable from LCD screen
6. VFD shall also have additional analog inputs – VFD speed in, analog output – VFD speed output, digital inputs – Start/Stop, and digital outputs – VFD fault, VFD running, VFD in remote, VFD output current low, etc. in Ethernet.

H. System Program providing built-in drive control or application specific configuration capability

I. Diagnostic Features and Fault Handling
   1. The VFD shall include a comprehensive microprocessor based digital diagnostic system that monitors its own control functions and displays faults and operating conditions.
   2. A “Fault Log” shall be accessible via a RS-232, RS-422, or RS-485 serial link as well as line-by-line on the keypad display and via Ethernet. The "FAULT LOG" shall record, store, display and output to a serial port upon demand, the following for the 64 most recent events:
      a. Date and time of day.
      b. Type of fault.
      c. All faults and events shall be stored and displayed in English, not fault codes.
   3. A "HISTORIC LOG" shall record, store, and output to a RS-232, RS-422, or RS-485 serial link port upon demand, the following selectable control variables at 1 msec. intervals for the 58 intervals immediately preceding and the 20 intervals immediately following a fault trip:
      a. Torque demand.
      b. Torque command.
      c. Torque feedback.
      d. Torque error.
      e. Torque maximum.
      f. Current demand.
      g. Peak current.
      h. Motor current.
      i. DC bus voltage.
      j. Line voltage.
      k. Velocity demand.
      l. Velocity reference.
      m. PI min/max limit.
      n. Boost.
      o. VFD mode (Auto/Manual).

PART 3 EXECUTION

3.01 PRE-DELIVERY TESTING COORDINATION

A. The VFD manufacturer shall fully test each VFD unit before shipping to the job site. Certified test reports shall be submitted to the Engineer/Owner as part of the equipment shipment.

3.02 STARTUP AND TRAINING

A. A trained technician shall be provided for startup assistance and training.

B. Services of a qualified technical representative who shall adequately supervise the installation and testing of and start up of all equipment furnished under this Contract and instruct the installation personnel and the Owner’s operating personnel in its maintenance and operation as outlined in the General Conditions.

3.03 SPARE PARTS

A. The following spare parts shall be furnished:
   1. One keypad assembly.
   2. One spare VFD NEMA 1 VFD drive, same model as supplied.

3.04 FIELD QUALITY CONTROL

A. Functional Test:
   1. Conduct on each VFD.
   2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
   3. Vibration Test: Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation, shall not develop amplitudes of vibration exceeding limits recommended by current edition of Hydraulic Institute Standards. Where pumps and motors are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
   4. Record test data for report.

B. Performance Test:
   1. Conduct on each VFD.
   2. Perform under actual or approved simulated operating conditions.
   3. Test for continuous 48-hour period without malfunction.
   4. VFD technician shall adjust the carrier frequency as needed to balance between the noise and motor winding heating, if applicable for the VFD supplied.
   5. Demonstrate performance by operating the continuous period while varying the application load, as the input conditions allow, in order to verify system performance.
   6. Record test data for report.

END OF SECTION

SECTION 16500

LIGHTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
  1. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
  2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
  3. Uniform Building Code (UBC): Section 2329, Earthquake Requirements.
  4. Underwriters Laboratories, Inc. (UL):
     a. 595, Standard for Safety Marine-Type Electric Lighting Fixtures.
     b. 844, Standard for Safety Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
     c. 924, Standard for Safety Emergency Lighting and Power Equipment.

1.02 SUBMITTALS

A. Shop Drawings:
  1. Interior Luminaires:
     a. Catalog data sheets and pictures.
     b. Luminaire finish and metal gauge.
     c. Lens material, pattern, and thickness.
     d. Candle power distribution curves in two or more planes.
     e. Candle power chart 0 to 90 degrees.
     f. Lumen output chart.
     g. Average maximum brightness data in foot lamberts.
     h. Coefficients of utilization for zonal cavity calculations.
     i. Mounting or suspension details.
     j. Heat exchange and air handling data.
  2. Exterior Luminaires:
     a. Catalog data sheets and pictures.
     b. Luminaire finish and metal gauge.
     c. Lens material, pattern, and thickness.
     d. IES lighting classification and isolux diagram.
     e. Fastening details to wall or pole.
     f. Ballast type, location, and method of fastening.
     g. For light poles, submit wind loading, complete dimensions, and finish.
  3. Lamps:
     a. Voltages.
     b. Colors.
     c. Approximate life (in hours).
     d. Approximate initial lumens.
     e. Lumen maintenance curve.
     f. Lamp type and base.
     g. Copy of lamp order, including individual quantities, for Project.
  4. Ballasts:
     a. Type.
     b. Wiring diagram.

c. Nominal watts and input watts.
d. Input voltage and power factor.
e. Starting current, line current, and restrike current values.
f. Sound rating.
g. Temperature rating.
h. Efficiency ratings.
i. Low temperature characteristics.
j. Emergency ballasts rating and capacity data.

5. Photo-Time Control:
   a. Wiring diagram.
   b. Contact ratings.
6. Photocells:
   a. Voltage, and power consumption.
   b. Capacity.
   c. Contacts and time delay.
   d. Operating levels.
   e. Enclosure type and dimensions.
   f. Temperature range.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

1.04 LATEST LED TECHNOLOGY

A. LED (light emitting diode) technology is changing rapidly and most of the LED light fixtures specified in the project may no longer available when the project is going into construction phase. Light fixture supplier shall provide and equivalent or greater LED light fixtures (lumen output) without additional cost to the Owner and get approval from Engineer.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of Work of this section is located in the Luminaire Schedule on Drawings.

B. Feed-through type, or separate junction box.

C. Ballasts: Two-lamp when possible.

D. Tandem wired for three-lamp, fluorescent fixtures.

E. Wire Leads: Minimum 18 AWG.

F. Component Access: Accessible and replaceable without removing luminaire from ceiling.

G. Soffit Installations:
   1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.
   2. Ballast: Removable, prewired.

H. Exterior Installations:
   1. UL Labeled: SUITABLE FOR WET LOCATIONS.
   2. Ballast: Removable, prewired.
   3. When factory-installed photocells are provided, entire assembly shall have UL label.

I. Emergency Lighting:
   1. Power Pack: Self-contained, 120-volt transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
   2. Lighted, push-to-test indicator.
   3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
   4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
   5. Capable of protecting against excess charging and discharging.

2.02 LAMPS

A. Fluorescent:
   1. Type Efficiency: Energy.
   2. Color: Cool white.

B. LED:
   1. Type Efficiency: Energy.
   2. Color: as stated on plans.

C. Manufacturers:
   1. Sylvania.
   2. General Electric.
   3. North American Phillips.
   4. Or approved equal.

2.03 BALLASTS

A. General:
   1. Meet requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.
   2. Certified by electrical testing laboratories to conform to Certified Ballast Manufacturer's specifications.

B. LED:
   1. LED fixture driver shall be as per the LED light fixture manufacturer’s recommendation if not otherwise noted on the drawings.
   2. LED driver shall be fixed or dimmable version, as noted on the drawings.

2.04 LIGHTING CONTROL AND SWITCHES

A. Photocell:
   1. Automatic ON/OFF switching photo control.
   2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
   3. Setting: ON at dusk and OFF at dawn.
   4. Time delay feature to prevent false switching.

5. Field adjustable to control operating levels.
6. Manufacturers:
   a. Tork.
   b. Paragon.
   c. Or approved equal.

B. Light Switches: Occupancy Sensor Type (Infrared Wall-Switch)
   1. Not used.

C. Light Switches: Non-occupancy Sensor Type (Only use when indicated on drawings)
   1. Not used.

2.05 POLES

A. Rating (with Luminaire): All pole installation shall be suitable for wind loading and appropriate gust factor per applicable zone of installation as defined in the Florida Building Code. The contractor shall include with the shop drawing submittal, a pole wind loading calculation signed and sealed by a structural engineer registered in Florida showing that the proposed installations will meet the given wind loading requirement.

B. Material: Extruded aluminum or concrete, as shown on plans.

2.06 EMERGENCY BALLAST

A. In accordance with UL 924.

B. Nickel cadmium battery, charger, and electronic circuitry in metal case plus ac ballast.

C. Solid state charging indicator monitoring light and double-pole test switch.

D. Capable of operating one fluorescent lamp for a period of 90 minutes with output of 1,100 to 1,200 lumens.

E. Manufacturers:
   1. MagneTec Jefferson.
   2. Bodine.
   3. Radiant.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:
   1. Install in accordance with manufacturer's recommendations.
   2. Provide proper hangers, pendants, and canopies as necessary for complete installation.
   3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building and to concrete pole bases required to safely mount.
   4. Install plumb and level.

5. Mounting heights shown for wall mounted or pendant mounted luminaires are measured from bottom of luminaire to finished floor or finished grade, whichever is applicable.
6. Install each luminaire outlet box with galvanized stud.

B. Pendant Mounted:
1. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
2. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
3. Provide twin-stem hangers on single luminaires.

C. Pole Mounted:
1. Provide precast concrete base.
2. Provide branch circuit in-line fuses in pole base handhole.

D. Swinging Type:
1. Not used.

E. Finished Areas:
1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
   a. Flush and Recessed Luminaires: Locate minimum 1 foot from luminaire.
   b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
   a. Provide wiring of temperature rating required by luminaire.
   b. Provide flexible steel conduit.
7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
   a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
   b. Tensile strength of chain or wire, and method of fastening to structure shall be adequate to support weight of luminaire.
   c. Fasten chain or wire to each end of luminaire.

F. Unfinished Areas: Locate luminaires to avoid either conflict with other building systems or blockage of luminaire light output.
1. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

3.02 LAMPS

A. Provide in each fixture, the number and type for which the fixture is designed, unless otherwise noted.

3.03 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.04 LIGHTING CONTROL

A. Outdoor Luminaires: Photocells switch lights ON at dusk and OFF at dawn, unless otherwise noted on drawings.

3.05 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fluorescent fixture housing adjacent to ac ballast.

B. Install monitoring light and double-pole switch adjacent to light fixture.

C. Wire in accordance with manufacturer's wiring diagrams.

3.06 OCCUPANCY SENSOR WALL-SWITCH

Not used.

3.07 CLEANING FOLLOWING CONSTRUCTION

A. Remove all labels and other markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up all painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace all defective lamps at time of Substantial Completion.

END OF SECTION

SECTION 16950

ELECTRICAL TESTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards, which may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. 450, Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations.
      b. C2, National Electrical Safety Code.
      c. C37.20.1, Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
      d. C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear.
      e. C37.20.3, Metal-Enclosed Interrupter Switchgear.
      f. C62.33, Standard Test Specifications for Varistor Surge- Protective Devices.
   2. American Society for Testing and Materials (ASTM):
      a. D665, Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
      b. DS77, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      c. D923, Standard Test Method for Sampling Electrical Insulating Liquids.
      d. D924, Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      e. D971, Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method.
      f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
      h. D1500, Standard Test Method for ASTM Color of Petroleum Products.
      i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
      j. D1533, Standard Test Methods for Water in Insulating Liquids.
      k. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
      l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop- Weight Method.
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
      b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.
      c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

d. 95, Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
e. 118, Standard Test Code for Resistance Measurement.
f. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
4. National Electrical Manufacturers Association (NEMA):
a. AB 4, Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
b. PB 2, Deadfront Distribution Switchboards.
c. WC 7, Cross-Linked-Thermosetting-Polyethylene- Wire and Cable for the Transmission and Distribution of Electrical Energy.
d. WC 8, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
a. 70, National Electrical Code (NEC).
b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.02 SUBMITTALS

A. Administrative Submittals: Submit 30 days prior to performing inspections or tests:
1. Schedule for performing inspection and tests.
2. List of references to be used for each test.
3. Sample copy of equipment and materials inspection form(s).
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

B. Quality Control Submittals: Submit within 30 days after completion of test:
1. Test or inspection reports and certificates for each electrical item tested.

C. Contract Closeout Submittals:
1. Operation and Maintenance Data:
a. In accordance with Section 01782, OPERATION AND MAINTENANCE DATA.
b. After test or inspection reports and certificates have been reviewed by ENGINEER and returned, insert a copy of each in operation and maintenance manual.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:
1. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:
   1. Scheduled with ENGINEER prior to de-energization.
   2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify ENGINEER at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Section FACILITY STARTUP.

B. Tests and inspection shall establish that:
   1. Electrical equipment is operational within industry and manufacturer's tolerances.
   2. Installation operates properly.
   3. Equipment is suitable for energization.
   4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, and other applicable devices in accordance with values established by the short circuit and coordination study as specified in Section 16015, ELECTRICAL SYSTEMS ANALYSIS.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform ENGINEER of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:
   1. Electrical items that fail tests.
   2. Active components not operating in accordance with manufacturer's instructions.
   3. Damaged electrical equipment.

O. Electrical Enclosures:
   1. Remove foreign material and moisture from enclosure interior.
   2. Vacuum and wipe clean enclosure interior.
   3. Remove corrosion found on metal surfaces.
   4. Repair or replace, as determined by ENGINEER, door and panel sections having dented surfaces.
   5. Repair or replace, as determined by ENGINEER, poor fitting doors and panel sections.
   6. Repair or replace improperly operating latching, locking, or interlocking devices.
   7. Replace missing or damaged hardware.
   8. Finish:

   Provide matching paint and touch up scratches and mars.

   If required due to extensive damage, as determined by ENGINEER, refinish the entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.02 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Inspect Each Individual Exposed Power Cable No. 6 and Larger For:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.
      c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
      d. Color coding conformance with specifications.
      e. Proper circuit identification.
   2. Mechanical Connections For:
      a. Proper lug type for conductor material.
      b. Proper lug installation.
      c. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by manufacturer.

3. Shielded Instrumentation Cables For:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
1. Insulation Resistance Tests:
   a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
   b. Evaluate ohmic values by comparison with conductors of same length and type.
   c. Investigate values less than 50 megohms.
   d. Utilize 1,000V dc megohmmeter for 600V insulated conductors.
2. Continuity test by ohmmeter method to ensure proper cable connections.

3.03 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.
6. Proper phase barrier material and installation.
7. Verify that fuse sizes and types correspond to one-line diagram.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:
1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switchblade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.04 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:
1. Proper mounting.
2. Proper conductor size.

3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:
1. Insulation Resistance Tests:
a. Utilize 1,000-volt dc megohmmeter for 480- and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
d. Test values to comply with NETA ATS, Table 10.2.
2. Contact Resistance Tests:
a. Contact resistance in microhms across each pole.
b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
a. Long-time minimum pickup and delay.
b. Short-time pickup and delay.
c. Ground fault pickup and delay.
d. Instantaneous pickup by run-up or pulse method.
e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
f. Trip times shall be within limits established by NEMA AB 4, Table 5-3.
g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4.

3.05 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:
1. Equipment and circuit grounds in motor control centers, panelboards, switchboards, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control centers, panelboards, switchboards, and switchgear assemblies for proper termination and tightness,
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
1. Fall-Of-Potential Test:
a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
b. Main ground electrode system resistance to ground to be no greater than 5 ohms.

2. Two-Point Direct Method Test:
    a. In accordance with IEEE 81, Section 8.2. 1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
    b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.06 LOW VOLTAGE MOTOR CONTROL OR STARTER PANELS

A. Visual and Mechanical Inspection:
1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check Door and Device Interlocking System By:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Key Interlocking Systems For:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check Nameplates for Proper Identification Of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
10. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify that current and potential transformer ratios conform to Contract Documents.
12. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Thermographic Survey:
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees C, or less.
13. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of the motor control center.

15. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
16. Exercise active components.
17. Inspect Contactors For:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector and circuit breaker with motor characteristics and power factor correction capacitors for proper size.
20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:
1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 10.2.
2. Overpotential Tests:
    a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 7.1.2.
    b. Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.
    c. Test results evaluated on pass/fail basis.
3. Current Injection Through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
4. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal boards and each device terminal.
    c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components.
        1) 1) Insulation resistance to be 1 megohm minimum.
5. Operational test by initiating control devices to affect proper operation.

3.07 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.

3. Proper operation of indicating devices.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check Door and Device Interlocking System By:
   a. Closure attempt of device when door is in OFF or OPEN position.
   b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Key Interlocking Systems For:
   a. Key captivity when device is in ON or CLOSED position.
   b. Key removal when device is in ON or CLOSED position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   e. Existence of other keys capable of operating lock cylinders.
      1) Destroy duplicate sets of keys.
9. Check Nameplates for Proper Identification Of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Control switch.
   d. Pilot light.
   e. Control relay.
   f. Circuit breaker.
   g. Indicating meter.
10. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified,
11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench thermographic survey applied to bolted joints.
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees C, or less.
12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature.
14. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor logs and connections.
15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.1.1.
      b. Each phase of each bus section.

c. Phase-to-phase and phase-to-ground for 1 minute.
d. With switches and breakers open.
e. With switches and breakers closed.
f. Control wiring except that connected to solid state components.
g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Overpotential Tests:
   a. Applied ac or dc voltage and test procedure in accordance with ANSI C37.20.3 and NEMA PB 2.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.
4. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.08 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:
   1. Medium voltage switchgear and transformer.
   2. Switchboard.
   3. Low voltage motor control center.
   4. Panelboard.

B. Provide a thermographic survey of feeder conductors No. 2 and larger terminating at:
   1. Motors rated 30 horsepower and larger.
   2. Low voltage disconnect switches.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading.

E. Do not perform survey on equipment operating at less than 20 percent of rated connected operating load.

F. Utilize Thermographic Equipment Capable Of:
   1. Detecting emitted radiation.
   2. Converting detected radiation to visual signal.
   3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients Of:
   1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
   2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
   3. 16 degrees C and above indicates deficiency that is to be corrected immediately.

H. Provide Written Report Of:
   1. Areas surveyed and the resultant temperature gradients.
   2. Locations of areas having temperature gradients of 3 degrees C or greater.
   3. Cause of heat rise and actions taken to correct the cause of heat rise.
   4. Detected phase unbalance.

END OF SECTION

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SECTION 17000

INSTRUCTIONMENTATION AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor shall furnish, install, and place into service operating process instrumentation, control systems, and panels including accessories, related to this facility, all as shown on plans and specified herein.
   1. Existing plant systems must remain operational during construction. Nighttime and/or other off hours work may be required to support plant operations and shall be included in the contractor's bid.
   2. The instrument contractor is responsible to "As-Build" all existing control panels and to provide all demolition and modification as necessary for the installation of the new I/O in the existing local control panels.
   3. Equipment rendered obsolete by this construction must be removed from the existing panels. Equipment previously abandoned must also be removed from the panels. Functioning equipment present in these panels must remain functional and will be included on the instrument contractor's "As-Built" drawings. No existing equipment, with the exception of the field wires and panel, may be reused as part of the new control system. New power supplies, surge suppressors, terminal strips, etc. for all I/O to be connected to the new control system must be provided new. The instrument contractor is responsible to provide completed panels that are clean, functional and present a professional workman-like appearance.
   4. All wires in control panels must be permanently tagged and shown on the as-built drawings. This includes all spare and abandoned wires and cables. Spare and abandoned cables are to be taped and left coiled in the panels for future use. Cable and wire numbers are to be assigned by the contractor, documented, and controlled to prevent duplicate numbers. The contractor shall turn over to the owner, at the project conclusion, a cable and wire list showing assigned numbers and their physical location in the plant.
   5. See electrical drawings and specifications for additional work required of the instrument contractor as part of this project to supply demolition instructions, relocation and modification instructions for equipment not necessarily shown on the instrument drawings.
   6. Furnish and install one new BFP master control panel (PCP-DW) as shown on drawings and as per this specification complete in place. New PLC panel shall consist a minimum of a Allen-Bradley Compactlogix 5370 L3 controller (Model:1769-L33ER) with associated I/O system, power supply, fiber optic patch panel, panelview plus touch screen, ethernet switch, media converter (as needed), patch cables, relays, terminal blocks, etc. as required for a complete and working PLC system in place.

7. Furnish and install one new stand alone Panelview HMI touch screen in a NEMA 1 painted steel enclosure in the 2nd floor Laboratory Room – Dewatering Building. New HMI touch screen panel shall be wall mount type and provide all necessary mounting hardware. New HMI touch screen panel shall be provided with one HMI touch screen mounted on the door of enclosure, main breaker, surge arrestor, terminal blocks, 550VA UPS, panel name tag, etc. for a complete and working HMI panel in place.
8. Furnish and install new instruments as shown on drawings and as per this specification.
9. Existing BFP feed pump pressure transmitters, and flowmeters will be installed as part of the on-going CMAR project. They will not be connected to PLC nor 120V power source and Contractor shall be responsible to setup and connected them as shown on drawings and as needed for a complete and functional instrument.
10. Perform loop check for the Belt Filter Press Control panel, conveyor control panels, and other packaged systems supplied by packaged system suppliers.
11. After completion of the project, Instrumentation (I&C) Contractor shall provide laminated panel wiring diagrams (11x17) inside each new PLC and RIO panel, including new I/O points added to the existing panels. Panel wiring diagrams shall incorporate the red-line mark-ups during the start-up and testing phase. Wiring diagrams without including the red-line mark-ups will be rejected and will need to recreate them without additional cost to the Owner.

B. Work Includes: Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and OWNER training for a complete Instrumentation and Control System.
   1. Major parts are:
      a. Modification of existing PCP-2A remote I/O panel at Dewatering Building – 2nd floor to add fiber optic patch panel and fiber optic connection as shown on drawings. Refer to communication block diagram for additional requirements.
      b. New PLC panel (PCP-DW) at Dewatering Building – 1st floor Electrical Room as shown on drawings and as describes in this specification.
      c. New BFP#1 and new BFP#2 local control panels are to be provided per the BFP supplier as per specification 11362. I&C Contractor and coordinate with BFP's supplier software programmer for identify each scope of PLC programming and perform accordingly. Coordinate with packaged belt filter press supplier for interfacing with plant PLC and SCADA system and as shown on N-drawings. Provide new fiber optic cables with appropriate connectors as shown on drawings and as required. Refer to specification 11362 for control function description of BFP and associated system. I&C Contractor shall be responsible for programming of the remaining control functions of other components at the Dewatering Building.
      d. Contractor shall program the plant SCADA system, including SCADA server, Historian server, etc. for the entire project. Existing plant SCADA system is CitectSCADA system.

e. BFP’s software programming is responsible for PLC programming BFP control strategy, including horizontal and incline conveyor, polymer dilution system, etc. in the BFP master control panel PLC system. I&C Contractor shall responsible for PLC programming associated with remaining systems in the dewatering building system. New PCP-DW PLC will need to be programmed by both BFP supplier and I&C Contractor for different components of the Dewatering system and it will require communication between both software programmers of BFP supplier and I&C Contractor so that one control function or I/O point is not to overwrite to another programmer’s control function or I/O point in the same PLC.
f. Perform loop check for all signals and control points.
g. Acceptance Testing, including acceptance test.

C. Instrument and Control (I&C) Supplier work scope:
1. For I&C equipment and ancillaries provide the following:
   a. Completing detail design.
   b. Required Submittals.
   c. Equipment and ancillaries.
   d. Instructions, details, and recommendations to, and coordination with, Contractor for proper installation.
   e. Verify readiness for operation.
   f. Verify the correctness of final power and signal connections.
   g. Adjusting and calibrating.
   h. Starting up.
   i. Testing and coordination of testing.
   j. Training.
2. Verify following work not by I&C Supplier is provided:
   a. Correct type, size, and number of signal wires with their raceways.
   b. Correct electrical power circuits and raceways.
   c. Correct size, type, and number of I&C related pipes, valves, fittings, and tubes.
   d. Correct size, type, materials, and connection of process mechanical piping for in-line primary elements.
3. For equipment not provided under I&C Supplier, but directly connected to equipment required by I&C Supplier:
   a. Obtain from Contractor, manufacturer’s information on installation, interface, function, and adjustment.
   b. Coordinate with Contractor to allow required interface and operation with I&C System.
   c. For operation and control, verify that installations, interfacing signal terminations, and adjustments have been completed with manufacturer’s recommendations.
   d. Test to demonstrate required interface and operation with I&C System.
   e. Examples of items in this category, but not limited to the following:
      1) Valve operators, position switches, and controls.
      2) Chemical feed pump and feeder speed/stroke controls.
      3) Automatic samplers.
      4) Motor control centers.
      5) Adjustable speed drive systems.
   f. Examples of items not in this category:
      1) Internal portions of equipment provided under Division 16, Electrical, that are not directly connected to equipment under I&C System.

2) Internal portions of I&C Systems provided as part of package systems and that are not directly connected to equipment provided under I&C System.

4. Wiring external to equipment provided by I&C Supplier:
5. Special control and communications cable: Provided by I&C Supplier.

D. Software Engineering work scope: PLC and SCADA programming shall be performed by the Contractor’s software programmer. HMI touchscreen (part of the new control panel) programming shall also be performed by the Contractor’s software programmer.

1.02 SINGLE INSTRUMENT SUPPLIER

A. The Contractor shall assign to the Single Instrument and Control (I&C) supplier full responsibility for the functional operation of all new instrumentation systems. The Contractor shall have said supplier perform all engineering necessary in order to select, to furnish, to program, to supervise installation, connection, to calibrate, to place into operation of all sensors, instruments, alarm equipment, control panels, accessories, and all other equipment as specified herein. The I&C supplier shall have a maintenance office within a 150 mile radius of the project.

B. The single instrument and controls supplier shall demonstrate his ability to successfully complete projects of similar sizes and nature. Provide references (including phone number and contact name) for at least three projects successfully completed in which the following tasks were performed: system engineering, documentation including panel assembly, schematics and wiring diagram, field testing, calibration and start-up, operator instruction and maintenance training.

C. The foregoing shall enable the Contractor and the Owner to be assured that the full responsibility for the requirements of this Section shall reside in an organization which is qualified and experienced in the water management field and its process technology on a functional systems basis.

D. The single I&C supplier shall have a UL approved shop and shall build all panels according to UL 508A.

E. Instrumentation and Controls supplier shall be Blackburn Controls, Curry Controls, Commerce Controls, Inc., Rocha Controls, and Revere Controls, CEC Controls, Sanders and Company, or Owner approved equal.

F. The single software engineering supplier shall demonstrate his ability to successfully complete projects of similar sizes and nature. Provide references (including phone number and contact name) for at least three projects successfully completed in which the following tasks were performed: ladder logic programming, computer based SCADA system configuration, documentation, field testing, start-up, and operator instruction.

1.03 INSTALLATION WORK

A. Nothing in this part of the Specifications shall be construed as requiring the Contractor to utilize personnel supplied by his assigned instrument manufacturer's organization, or any division thereof, to accomplish the physical installation of any elements, instruments, accessories or assemblies specified herein. However, the Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, instruments, accessories and assemblies; portions of their work shall be supervised or checked as specified in Part 3, herein.

1.04 PREPARATION OF SUBMITTAL OF DRAWINGS AND DATA

A. It is incumbent upon the Contractor to coordinate the work specified in these Sections so that a complete I&C system for the facility shall be provided and shall be supported by accurate Shop and record Drawings. As a part of the responsibility as assigned by the Contractor, the Single I&C supplier shall prepare and submit through the Contractor, complete organized Shop Drawings, as specified in Part 2.02, herein. Interface between instruments, motor starters, etc. shall be included in his Shop Drawing submittal.

B. During the period of preparation of this submittal, the Contractor shall authorize direct, informal liaison between his Single I&C supplier and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as specified may be authorized informally by the Engineer, but these shall not alter the scope of work or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant formal exception to, or variation from these Specifications.

1.05 ADDITIONAL TECHNICAL SERVICES

A. At no separate additional cost to the Owner, the Contractor shall provide the following services of qualified technical representatives of the Single I&C supplier (See Part 3, herein).
   1. To supervise installation and connection of all instruments, elements, and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as pumps, valves, and chemical feeders;
   2. To make all necessary adjustments, calibrations and tests; and to instruct plant operating and maintenance personnel on instrumentation. This time shall be in addition to whatever time is required for other facets of work at the site, and shall be during the Owner's normal working days and hours.
   3. To terminate and test all fiber optic cable and effected devices.

1.06 GUARANTEE

A. The Contractor shall guarantee all equipment and installation, as specified herein, for a period of one (1) year following the date of completion of the work. To fulfill this obligation, the Contractor shall utilize technical service personnel designated by the Single I&C supplier to which the Contractor originally assigned project responsibility for instrumentation. Services shall be performed within two (2) calendar days after notification by the Owner.

1.07 ADDITIONAL PROVISIONS

A. The applicable provisions of the following Sections under Electrical Work shall apply to work and equipment specified herein, the same as if stated in full, herein:
   1. Codes and Standards
   2. Equipment, Materials and Workmanship
   3. Testing
   4. Grounding
   5. Equipment Anchoring
   6. Conductor and Equipment Identification
   7. Terminal Cabinets and Control Compartments
   8. Process Control Devices

1.08 NEWEST MODEL COMPONENTS

A. All meters, instruments, and other components shall be the most recent field proven models marketed by their manufacturers at the time of submittal of Shop Drawings unless otherwise specified to match existing equipment. All technical data publications included with submittals shall be the most recent issue.

1.09 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. The instrumentation drawings were developed from past record drawings and information supplied by the Owner.

B. Before submitting a bid, visit the site and determine conditions at the site and at all existing structures in order to become familiar with all existing conditions and instrumentation and control systems which will, in any way or manner, affect the work required under this Contract. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.

1.10 RELATED WORK

A. Division 16 -Electrical

B. Division 11 -Equipment

C. Division 13 - Special Construction

1.11 COORDINATION MEETINGS

A. The Instrumentation (I&C) Contractor shall schedule a minimum of three (3) mandatory coordination meetings. The meeting shall be held at the Owner's offices and shall include, as a minimum, attendance by all key personnel involved (e.g. the Owner, the Engineer, the I&C Contractor Engineer, BFP supplier and the Electrical Subcontractor, etc.).

B. The meeting shall be held in advance of the first I&C Contractor shop drawing submittal. The purpose of the meeting shall be for the I&C Contractor to: Summarize their understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery milestone dates; provide a forum for the I&C Contractor, Engineer, and Owner to coordinate hardware and software related issues; and request any additional information required from the Engineer and/or Owner. Also, the I&C Contractor shall coordinate conduit and wire requirements for all instrumentation and controls with the Electrical Subcontractor before electrical work is begun. The I&C Contractor should bring draft working drawings to the meeting to provide the basis for the Engineer and Owner's input into their development.

C. The second meeting shall be held after the first complete instrumentation and control (hardware and software) shop drawing package has been reviewed by the Owner and Engineer and returned to the I&C Contractor. The purpose of the second meeting is to discuss comments made on the submittal package; to refine scheduled milestone dates; coordinate equipment installation activities; and provide a forum for any further required coordination.

D. The third meeting shall be held one month prior to start-up and field loop check/testing. The purpose of this third meeting is to discuss any remaining coordination requirements.

PART 2 PRODUCTS

2.01 INSTRUMENTATION CRITERIA

A. DESIGNATION OF COMPONENTS:

1. In these Specifications and on the Drawings, all systems, meters, instruments, and other elements are represented schematically, and are designated by numbers, as derived from criteria in Instrument Society of American Standard ANSI/ISA S5.1-1973. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, data sheets, and similar materials. Any other symbols, designations, and nomenclature unique to the manufacturer's standard methods shall not replace these prescribed above, used, herein and on the Drawings.

B. SIGNAL CHARACTERISTICS:

1. Signals shall be electrical, as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Electrical signals outside control panel(s) shall be 4 to 20 milliamperes DC, except as noted. Signals within enclosures may be 1-5 volts DC.

C. MATCHING STYLE, APPEARANCE, AND TYPE:

1. All instruments to be panel mounted at the control panels shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be of one (1) manufacturer.

D. ACCURACY AND REPEATABILITY:

1. The overall accuracy of each instrumentation system or loop shall be as prescribed in the Specifications for that system or loop. Each system's accuracy shall be determined as a probable maximum error; this shall be the square-root of the sum of the squares of certified "accuracy s" of certain designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual electronic instrument shall have a minimum accuracy of ±0.7 percent of full scale and a minimum repeatability of ±0.4 percent of full scale unless otherwise specified. Instruments which do not conform to or improve upon these criteria are not acceptable.

E. SIGNAL ISOLATORS, CONVERTERS, AND POWER SUPPLIES:

1. Signal isolators shall be furnished and installed in each measurement and control loop, wherever required, to insure adjacent component impedance match or where feedback paths may be generated. Signal converters shall be included where required to resolve any signal level incompatibilities. Signal power supplies shall be included, as required by the manufacturer's instrument load characteristics, to insure sufficient power to each loop component.

F. ALTERNATIVE EQUIPMENT OR METHODS:

1. Equipment or methods requiring redesign of any project details are not acceptable without prior approval of the Engineer. Any changes inherent to a proposal alternative shall be at no additional cost to the Owner. The required approval shall be obtained in writing by the I&C Subcontractor through the Contractor prior to submittal of Shop Drawings and data. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method specified, or shall include evidence that a specified component is not available. Otherwise, alternative equipment (other than direct, equivalent substitutions) and alternative methods shall not be proposed.

2.02 SHOP DRAWINGS AND DATA

A. CONTENT:

1. The Contractor shall submit detailed Shop Drawings and data prepared and organized by the Single I&C supplier designated at the time of bidding. The quantity of submittal sets required shall be six (6). These Drawings and data shall be submitted as a complete bound package at one time within 80 calendar days after date of Notice to Proceed and shall include:
    a. Drawings showing definite diagrams for every instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ISA Standard S5.4, each having the format of ISA Standard S5.1 as used on the Project Drawing. (Each system or loop diagram shall be drawn on a separate Drawing sheet.)
    b. Data sheets for each component, together with a technical product brochure or bulletin. The data sheets shall show:
        1) Component function description used herein and on the Drawings;
        2) Manufacturer's model number or other product designation;
        3) Project tag number used herein and on the Drawings;

4) Project system loop of which the component is a part;
5) Project location or assembly at which the component is to be installed;
6) Input and output characteristics;
7) Scale range and units (if any) and multiplier (if any);
8) Special requirements or features:

c. A complete index shall appear in the front of each bound submittal volume. A separate technical brochure or bulletin shall be included with each instrument data sheet. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin may cover all identical uses of that instrument in that system. Each brochure or bulletin shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

d. Drawings showing both schematic and wiring diagrams for control circuits. Complete details on the circuit interrelationship of all devices within and outside each control panel shall be submitted first, using schematic control diagrams. Subsequent to return of this first submittal by the Engineer, piping and wiring diagrams shall be prepared and submitted for review by the Engineer; the diagrams shall consist of component layout Drawings to scale, showing numbered terminals on components together with the unique number of the wire to be connected to each terminal. Piping and wiring diagrams shall show terminal assignments from all primary measurement devices, such as flow meters, and to all final control devices, such as samplers, pumps, valves, and chemical feeders. The Contractor shall furnish all necessary equipment supplier's Shop Drawings to facilitate inclusion of this information by the I&C system supplier.
1) Schematic and wiring diagram criteria shall be followed as established in NEMA Standards Publication ANSI/NEMA 1CS-1-1978, "Industrial Control and Systems."

e. Assembly and construction Drawings for each control panel and for other special enclosed assemblies for field installation. These Drawings shall include dimensions, identification of all components, surface preparation and finish data, nameplates, and the like. These Drawings also shall include enough other details, including prototype photographs, to define exactly the style and overall appearance of the assembly; a finish treatment sample shall be included.

f. Installation, mounting and anchoring details for all components and assemblies to be field-mounted, including conduit connection or entry details.

g. Complete and detailed bills of materials. A master Bill of Materials listing all field mounted devices, control panels, and other equipment that shall be shipped to the job site. A Bill of Materials for each control panel listing all devices within the panel.

h. Modifications to existing equipment. A complete description of all proposed modifications to existing instrumentation equipment, control panels, control devices, cabinets, etc., shall be submitted with the Shop Drawings complete with detailed Drawings of the proposed modifications.

i. After completion of the project, I&C Contractor shall provide laminated panel wiring diagrams (11x17) inside each new PLC and RIO panel. Panel wiring diagrams shall incorporate the red-line mark-ups during the start-up and testing phase. Wiring diagrams without including the red-line mark-ups will be rejected and will need to recreate them without additional cost to the Owner

B. ORGANIZATION AND BINDING:

1. The organization of initial Shop Drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting "as built" conditions. Accordingly, the initial multiple copy Shop Drawing submittal shall be separately bound in 3-ring binders of the type specified under Part 2.03, herein, for the Technical Manuals.

2.03 TECHNICAL MANUALS

A. Two (2) final sets of technical manuals shall be supplied for the Owner, and one (1) final set shall be supplied for the Engineer, as a condition of acceptance of the project. Each set shall consist of one (1) or more volumes, each of which shall be bound in a standard size, three-ring, loose-leaf, vinyl plastic hard cover binder suitable for bookshelf storage. Binder ring size shall not exceed 3.0 inches.

B. Initially, two (2) sets of these manuals, unless otherwise noted, shall be submitted to the Engineer for favorable review after return of favorably reviewed Shop Drawings and data required under Part 3, herein. Following the Engineer's review, one (1) set shall be returned to the Contractor with comments. The sets shall be revised and/or amended as required and the requisite final sets shall be submitted to the Engineer fifteen (15) days prior to start-up of systems. Final technical manuals shall include the electronic version on a CD, DVD, or Flash drive.

C. In addition to updated Shop Drawing information to reflect actual existing conditions, each set of technical manuals shall include installation, connection, operating, trouble-shooting, maintenance, and overhaul instructions in complete detail. This shall provide the Owner with comprehensive information on all systems and components to enable operation, service, maintenance, and repair. Exploded or other detailed views of all instruments, assemblies, and accessory components shall be included together with complete parts lists and ordering instructions.

2.04 SPARE PARTS

A. The Contractor shall include, as part of the bid package, spare parts listed below and as listed in instrument list table of this specification. The I&C supplier shall be responsible for delivery of the spare parts, as directed by the Owner either during or after plant start-up.

B. Provide one spare PLC power supply, one spare I/O module for each type used, and one spare Ethernet switch, and media converter to the Owner.

2.05 CONTROL PANELS

A. GENERAL:

1. New control panels shall be furnished and installed under this Contract. They shall house the instrumentation, control devices, indicating lights, PLC’s, alarm chasses, displays, all necessary accessories, wiring and terminal blocks as necessary and as shown on the Drawings and as described herein. Control panel doors shall be equipped with a door latch kit or a fast operating clamp assembly as applicable. 120 volt AC control voltage in a control panel shall be supplied with a line noise suppressing transformer specified elsewhere in this Section. Each control panel shall be properly grounded and as such be provided with a ground terminal block. Control panels shall be properly sized for installation through new and existing entry ways and custom fit for locations as shown on the drawings. Each panel shall be provided with LED interior light that shall turn on when the control panel door is opened.

B. CONSTRUCTION:

1. Control Room:
   a. Control room panels shall be NEMA 12. The enclosures shall be manufactured of 14 gauge or thicker aluminum.
2. BUILDING:
   a. Control panels inside a building (not in a control room) shall be NEMA 12, 304 stainless steel 14 gauge construction. Control panels in corrosive areas shall be construed to be outdoors.
3. OUTDOOR:
   a. All outdoor control panels shall be NEMA 4X with drip shield kit, 3 point latch mechanism and 316 stainless steel 14 gauge construction.
4. COOLING:
   a. Control panels shall have sufficient cooling and/or ventilation not to exceed the maximum operating temperature of any of the internal components. Ambient temperature limits shall be 90 degrees F for indoor and 100 degrees F for outdoor control panels. Outdoor control panels with electronic equipment shall be furnished with sun shields around and on top of the control panels.
5. UPS:
   a. UPS: PLC and RIO Control Panels shall be furnished with a UPS to provide power to the PLC microprocessor and all PLC support, interface, and communication equipment for 10 minutes. UPS shall be manufactured by Best, model Ferrups or approved equal.

C. SIGNAL AND CONTROL CIRCUIT WIRING:

1. Wire TYPE and Sizes:
   a. Conductors shall be flexible stranded copper wire; these shall be U.L. listed Type THHN and shall be rated 600 volts. Wire for control signal circuits and alarm input circuits shall be 16 AWG. All instrumentation cables shall be shielded No. 20 AWG minimum with a copper drain wire. All special instrumentation cable such as between sensor and transmitter shall be supplied by the I&C supplier.

2. Wire INSULATION Colors:
    a. Conductors supplying 120 volt AC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120 volt AC control circuit conductors shall be red. All wires energized by a voltage source external to the control board(s) shall have yellow insulation. Insulation for all DC conductors shall be blue.
3. WIRING INSTALLATION:
    a. All wires shall be run in plastic wireways except (1) field wiring, (2) wiring run between mating blocks in adjacent sections, (3) wiring run from components on a swing-out panel to components on a part of the fixed structure, and (4) wiring run to panel mounted components. Wiring run from components on a swing-out panels to other components on a fixed panel shall be made up in tied bundles. These shall be tied with nylon wire ties, and shall be secured to panels at both sides of the "hinge loop" so that conductors are not strained at terminals.
    b. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and secured to the inside face of the panel using adhesive mounts.
    c. Wiring to rear terminals on panel mount instruments shall be run in plastic wireways secured to horizontal brackets run above or below the instruments in about the same plane as the rear of the instruments.
    d. Shields of shielded instrument cable shall only be grounded on one side of each cable run. The side to be grounded shall always be in the field as applicable.
    e. Care shall be exercised to properly insulate the ungrounded side, to prevent ground loops from occurring.
    f. Conformance to the above wiring installation requirements shall be reflected by details shown on the Shop Drawings for the Engineer's review.
4. Wire Marking:
    a. Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on all Shop Drawings. These numbers shall be marked on all conductors at every terminal using permanently marked heat-shrink plastic. Instrument signal circuit conductors shall be tagged with unique multiple digit numbers. Black and white wires from the circuit breaker panelboard shall be tagged including the one (1) or two (2) digit number of the branch circuit breaker.
5. TERMINAL Blocks:
    a. Terminal blocks shall be molded plastic with barriers and box lug terminals, and shall be rated 15 amperes at 600 volts. White marking strips, fastened securely to the molded sections, shall be provided and wire numbers or circuit identifications shall be marked thereon with permanent marking fluid. Terminal blocks shall be General Electric Type CR 151A1 with mounting rack, equivalent by Cinch-Jones or equal.

D. PAINTING:
1. Control panels shall be thoroughly cleaned and sandblasted per SSPC-SP-6 (Commercial Blast) after which surfaces shall receive a prime coat (Amercoat 185, Koppers 622HB, or equal) 3-mils dry, followed by two (2) or more finish coats (Amercoat 5401, Koppers 501, or equal) 3-mils dry, for a total thickness of the complete system of 6 mils. The finished color of the outside surfaces shall be selected by the Engineer. The inside surfaces shall have a white finish coat.
2. Exterior control panels shall be painted white on the exterior. A durable coating system with a five-year full replacement guarantee shall be used to coat the stainless steel panels. Defects in the coating systems include, but are not limited to, fading, color change, cracking peeling, or otherwise disbonding.

E. PLC Control Panel REQUIREMENTS:
1. All input/output hardware and interface equipment shall be provided by the computer & PLC system supplier for all specified inputs and outputs. Input/output hardware shall be plug-in modules (or equivalent I/O assembly and associated printed circuit board) in associated I/O rack assemblies.
2. All analog and discrete inputs and outputs shall be optically or transformer isolated for voltage surge protection and shall meet peak common mode and 3 kV surge to ground withstand capability (SWC) test as specified by ANSI C37.90A-197A (IEEE Standard 472-1974).
3. In the event a standard manufacturers product does not satisfy the above surge requirements, additional protective circuitry to suppress contact bounce and to protect transients from being recognized as data. Input/output modules shall be configured for ease of wiring and maintenance. The modules shall be connected to wiring arms which are movable to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals.
4. Input/output modules shall have individual indicators that show the on/off status of each input or output device connected to it. Remote I/O system shall be Allen-Bradley Controllogix family with Ethernet Communication module, no exception.
   a. ANALOG INPUT:
      1) The analog input subsystem shall accept 4-20 MA (1-5 volts across 250 ohms) signals which shall be multiplexed into one or more amplifiers and ADC's by one or more analog input multiplexers. The analog input multiplexers shall be of the solid state differential type and shall employ successive approximation or dual slope integration to digitize the sampled analog signals into a 12 bit binary value; with an accuracy of $\pm$0.05% of full scale. Input power supply shall be 24 volts DC from the I/O power supply subsystem where power is not supplied by the associated field instrument. Analog input cards shall match existing type and shall be Allen Bradley 1756-IF16 for Controllogix family and 1769-IF8 for Compactlogic family. Confirm model with Owner during submittal phase.
   b. DISCRETE INPUT:
      1) Dry Contact:
         a) The input subsystem shall sense the open or closed status of contacts at each scan interval. Sensing power shall be 24 volts DC from the I/O power supply subsystem.

2) Powered input:
   a) The input subsystem shall sense the status of 120VAC inputs at each scan interval. Power for inputs is derived from the source system or equipment. Discrete input cards shall match existing type and shall be Allen Bradley1756-IB32 for Controllogix family and 1769-IQ16 for Compactlogic family. Confirm model with Owner during submittal phase.

c. ANALOG OUTPUT:
   1) The analog output subsystem shall accept incremental signals from the process controller. A solid state digital to analog converter (DAC) shall be provided for each analog output. The incremental signals from the process controller shall increment or decrement the 4-20 MA output signal from each DAC. A 24 volt DC power supply shall be provided for analog outputs from the I/O power supply subsystem.
   2) The output of each DAC shall be continuously maintained and shall have a drift rate no greater than 2% in 24 hours. Each DAC shall have a 12 bit resolution and an accuracy of ±0.05% full scale. Analog output cards shall match existing type and shall be Allen Bradley 1756-OF8I for Controllogix family and 1769-OF8C for Compactlogic family. Confirm model with Owner during submittal phase.

d. DISCRETE OUTPUT:
   1) The discrete output subsystem shall be of the solid state type and shall generate maintained or momentary outputs as required to operate interposing relays provided in related circuitry. Diode protection (in addition to surge protection) shall be provided on all discrete outputs. The output contacts shall be rated 24 VDC/120 VAC, 5A SPDT. Discrete output cards shall match existing type and shall be Allen Bradley 1756-OB32 for Controllogix family and 1769-OB16 for Compactlogic family. Confirm model with Owner during submittal phase.

e. POWER SUPPLIES:
   1) Input/output (I/O) subsystem power supplies shall be provided for each PLC control panel and shall be sized to power all 2-wire and 4-wire discrete and analog DC circuits under full-load conditions including allowances for specified spares. The incoming power source to the I/O subsystem power supplies shall be 115 VAC from the associated panelboard. Transformation, rectification, and smoothing circuitry shall be furnished to provide a regulated 24 volt DC power supply. The DC power supply shall be converted to other DC voltage levels as required. Provide redundant 24VDC power supplies with diode protection and alarm (PLC input) in case of either power supply failure. Power supplier type shall match existing type and shall be Allen-Bradley1756-PA72 for Controllogix family and 1769-PA4 or 1769-PB4 for Compactlogix family. If power consumption is more than the listed model, supply larger power supply model.

f. PROGRAMMABLE CONTROLLER/CPU:
   1) Programmable controllers shall have dual Ethernet ports with DLR capability, 2MB memory, 16 I/O module expansion capacity and 32 Ethernet IP nodes. Controllers shall be Allen-Bradley Controllogix 1756 or Compactlogix 1769. The PLC shall backed by a CompactFlash or SD flash drive to be provided with the CPU.

g. UNINTERRUPTABLE POWER SUPPLIES:
   1) Provide UPS in each PLC control panel to provide uninterruptible power for the PLC, I/O, two wire instrument loops, all interposing relays, all PLC support, interface, and communication equipment for 10 minutes. UPS shall adhere to this section.

h. ADDITIONAL SPARE INPUTS AND OUTPUTS:
   1) The PLC power supply shall have sufficient capability to handle the power requirements for all the PLC components and I/O points, and spare I/O points. For new PLC panel, provide additional 25 percent input/output active spare capacity, 25 percent input/output expansion capability for future use.

2.06 ACCESSORIES

A. General purpose relays in the control panels shall be plug in type with contacts rated 10 amperes at 120 volts AC. The quantity and type of contacts shall be as shown on the Drawings. Each relay shall be enclosed in a clear plastic heat and shock resistant dust cover. Sockets for relays shall have screw type terminals. Relays shall be Potter and Brumfield Type KRP or KUP, Square-D Type K, or equal.

B. Time delay relays shall be solid state on-delay or off-delay type with contacts rated 10 amperes at 120VAC. Units shall include adjustable dial with graduated scale covering the time range in each case. Time delay relays shall be Agastat Series 7000, Omron series H3, SSAC type TDM or approved equal.

C. Additional slave relays shall be installed when the number or type of contacts shown exceeds the contact capacity of the specified relays and timers.

D. Switches and indicating lights shall be round 30.5-mm configuration, heavy-duty and corrosion-resistant. Legend plate shall be standard size square style laminate with white field and black markings as shown.

E. Indicating lights shall be LED type, unless otherwise noted. Lens color shall be as noted. All indicating lights shall be push-to-test type. Pushbuttons shall include full guard with flush button and selector switches shall include a black non-illuminated knob on switch, unless otherwise noted. Contact arrangement and configuration shall be as shown. Devices shall be by Cutler Hammer, General Electric, Square D, Allen-Bradley or approved equal.

F. Selector switches shall be of the rotary type with the number of positions as shown on the Drawings. Color, escutcheon engravings, contact configurations and the like shall be as shown. Devices shall be Cutler Hammer Type E-24, General Electric Type CR104, or equal.

G. Circuit breakers shall be single pole, 120 volt, 15 ampere rating or as required to protect wires and equipment and mounted inside the panels as shown.

H. Nameplates shall be supplied for identification of all field mounted elements, including flow meters and their transmitters. These nameplates shall identify the instrument, or meter, descriptively, as to function and system. These nameplates shall be fabricated from black-face, white-center, laminated engraving plastic. A nameplate shall be provided for each signal transducer, signal converter, signal isolator, each electronic trip, and the like, mounted inside the control panels. These shall be descriptive, to define the function and system of such element. Adhesives shall be acceptable for attaching nameplates. Painted surfaces must be prepared to allow permanent bonding of adhesives. Nameplates shall be provided for instruments, function titles for each group of instruments and other components mounted on the front of the control panels as shown. These nameplates and/or individual letters shall be fabricated from VI-LAM, Catalog No. 200, manufactured by N/P Company, or equivalent by Formica, or equal. Colors, lettering, style and sizes shall be as shown or as selected by the Engineer.

I. Solenoid Valves if not otherwise noted shall be globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation. Materials shall be brass globe valve bodies and Buna-N valve seats. The size shall be 1/4" normally closed. The coil shall be 115 VAC coil, NEMA 4 solenoid enclosure. Manufacturer shall be ASCO; Red Hat, or equal.

J. Fiber Optic Cables:

1. Fiber optic cables media shall consist of 62.5/125 (core/clad) micron graded index, multimode, plenum and riser rated, fiber optic cable containing at least six strings (3-pairs) of fibers, unless otherwise indicated in the drawings. The fiber optic cable shall be an all dielectric, heavy duty design. The fiber optic cable shall consist of multiple fibers each surrounded by a buffer tube, all contained in a flame retardant PVC outer jacket. The cable shall be designed for installations requiring high pull tensions for conduit pulls. The cable shall be gel filled or shall be provided with a water-swellable tape surrounding the buffer tube(s) to protect the fibers from moisture damage.
2. The fiber optic cable shall be designed to operate at an optical wavelength of 850 nm with a minimum bandwidth of 160 MHZ-km.
3. The fiber optic communications system shall utilize stainless steel ST style connectors for all fiber optic connections. The connector shall be designed for use with 62.5/125 micron cable, and shall be capable of operating a range of 0 to 80 degrees C. Each connector shall cause a maximum signal attenuation of 1.6 dB. Connectors shall be provided by Phoenix Digital, 3M, or approved equal. All fiber optic cables, including spares, shall be tested for performance and loss after termination and installation to verify that at least a 3 dB power safety margin is obtained between all transmitters and receivers. Test data from each fiber and safety margin calculations for each fiber path shall be provided to the Owner and Engineer after installation to verify conformance with this specification.
4. The fiber cable shall be similar and compatible with the existing system and will be responsibility of the Instrumentation Control Supplier. Utilization of existing cable is acceptable as long as the final installation is fully operational and in good working condition.

K. Fiber Optic Patch Panel:

1. Fiber optic termination cabinets shall be provided inside all control panels to terminate all active and spare incoming fiber optic tubing pairs. Cabinet/patch panels shall include a minimum of 12 fiber ports, or more if all 12 ports are used. Connectors shall be ST type, Corning, Black Box, or equal. Each port and fiber shall be labeled. A fiber optic cabinet/patch panel shall be provided in each rack to terminate all active and spare incoming fiber optic tubing pairs. Patch cables between the patch panel and the fiber optic device shall be multimode, ceramic terminated fiber optic cable with appropriate connectors (ST at patch panel, unless PLC components required a different type).

L. Ethernet Switch: Ethernet switch to be installed in the PLC control panel shall be Allen-Bradley Stratix Switch or Red Lion, or Owner/Engineer approved equal. Refer to Instrumentation drawings for fiber optic ports requirements for the Ethernet switch and provide accordingly. Contractor shall have the option to use media converter in lieu of Ethernet switch with fiber ports.

2.07 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) PROTECTION

A. GENERAL:

1. TVSS protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring.
2. Instruments shall be housed in a suitable case, properly grounded. Ground wires for all TVSS shall be connected to a good earth ground and where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate NEMA 4X junction box coupled to the enclosure.

B. POWER SUPPLY:

1. Protection of all 120 VAC instrument power supply lines shall be provided. Control panels shall be protected by line noise suppressing isolation transformers and TVSS. Field instruments shall be protected by TVSS. For control panels, the line noise suppressing isolation transformer shall be Topaz Series 30 Ultra isolators or approved equal. The suppressor shall be Edco HSP-121 or approved equal and U.L. 1449 compliant.

C. ANALOG SIGNALS:

1. Protection of analog signal lines originating and terminating not in the same building shall be provided by TVSS. For analog signal lines, the TVSS shall be Edco PC-642. For field mounted two-wire instruments, the TVSS shall be encapsulated in stainless steel pipe nipples and shall be Edco SS64 series or approved equal, and U.L. 497B compliant.
2. For field-mounted four-wire 120VAC instruments, the TVSS shall be in a NEMA 4X polycarbonate enclosure, Edco SLAC series or approved equal.

2.08 INSTRUCTIONS AND CONTROL EQUIPMENT SPECIFICATIONS

A. F1. Magnetic Flowmeter Element and Transmitter:
   1. Flow Element:
      a. Type: Pulsed DC electromagnetic induction type and shall provide a signal which is linear to the liquid flow rate.
      b. Functional/Performance:
      c. Power requirements: Match to converter/transmitter.
      d. Accuracy: Plus or minus 1 percent of rate (including converter/transmitter) and an ambient of 65 degrees Celsius.
      e. RFI protection - Provide RFI protection.
      f. Pressure rating - 240 PSI if 150 lb flanges are used, 700 PSI if 300 lb flanges are used.
      g. Temperature rating: Suitable for process liquid temperature up to 70 degrees Celsius
      h. Additional - Meter shall be capable of running empty indefinitely without damage to any component.
   2. Physical:
      a. Metering Tube: Stainless steel unless otherwise indicated.
      b. Flanges: ANSI 150-lb, carbon steel unless otherwise indicated. Provide 316 stainless steel on all sludge applications. Flangeless wafer type may be used if compatible with adjacent piping.
      c. Liner –TFE. For chemical application, provide liner material compatible with chemical to be measured.
      d. Electrodes - 316 stainless steel, bullet nosed or elliptical self cleaning type unless otherwise noted.
      e. Housing - Meters in below grade vaults, basements, etc, shall be designed for accidental submergence in 30-ft of water for 24 hours. Meters above grade shall be of splashproof/dripproof design unless otherwise noted. Where hazardous areas are indicated on the contract Drawings, the equipment shall be rated for that area.
      f. Mounting: Remote mounting with ANSI Class 150 flanges with alignment rings and hardware.
      g. Painting - All external surfaces shall be painted with a chemical and corrosion resistant epoxy finish.
      h. Accessories/Options Required:
      i. Factory calibration - All meters shall be factory calibrated. A copy of the report shall be in the O&M manual.
      j. Grounding - Meter shall be grounded per the manufacturers recommendation. Provide ground ring, ground wires, gaskets, etc., as required or as otherwise noted. All materials shall be suitable for liquid being measured.
      k. Manufacturers: ABB WaterMaster or Rosemount with remote transmitter or Owner/Engineer approved equal.
   3. Flow Converter/Transmitter:
      a. Type: Match to flow element.
      b. Functional/Performance:
      c. Power requirements: 120V AC plus or minus 10 percent.
      d. Accuracy: As defined for flow element.
      e. Temperature: minus 25 degrees C to plus 65 degrees C
      f. Output: Isolated 4-20 ma into 0 to 1000 ohms.
      g. Physical: Housing - NEMA 4X wall mount.

h. Accessories/Options Required:
i. Cable - Provide signal cable between magmeter and signal converter.
j. Indicator - Provide local indicator with scale engraved 0 to 100 percent which indicates actual converter output signal.
k. Totalizer - provide a seven digit, non-reset totalizer on the face of the enclosure and a scalable pulse output to drive the totalizer. The totalizer multiplier shall be a power of 10.
l. Zero Return Unit - Where indicated on the instrument device schedule provide a zero return unit. The unit shall be powered from the converter/transmitter and may be mounted in a separate NEMA 4X enclosure, the device shall drive the magmeter output to 4 ma DC on no flow conditions.
m. Mounting: 2 inch pipe stand. Mounting hardware shall be Type 316 stainless steel, unless otherwise noted on drawings.
n. Manufacturer: (same as flow element): ABB Model WaterMaster or Rosemount or Owner/Engineer approved equal.

B. P1. Pressure and Differential Pressure Transmitter (Electronic)
1. This specification covers the following services:
a. Absolute pressure.
b. Level inferred from pressure
c. Differential pressure.
d. Flow inferred from differential pressure.
e. Vacuum
1) Gauge and differential pressure transmitters shall be of the capacitance type with a field adjustable 10:1 input range. Span and zero shall be continuously adjustable externally over the entire range. Transmitter shall be of the smart type microprocessor-based. Transmitters shall be Nema 4X construction with 316 stainless steel process wetted parts, if not otherwise stated. Accuracy, including nonlinearity, hysteresis and repeatability errors shall be ± 0.1% of calibrated span. The maximum zero elevation and maximum zero suppression shall be adjustable to 150% of maximum span. Output shall be linear isolated 4-20 mA 24 VDC. Power supply shall be 24 VDC, two wire design. Each transmitter shall be furnished with a junction box, external zero and indicator calibrated in engineering units and mounting hardware as required. Overload capacity shall be rated at a minimum of 200% of maximum range. Each transmitter shall have a stainless steel tag with calibration data attached to body.
2) Range: 30 inches to 200 psig. Refer to the instrument schedule for calibrated span for the individual instrument(s).
3) Maximum Static Pressure: 2,000 psig.
4) Humidity: 10 to 100 percent non-condensing.
5) Sensing Element: Diaphragm type.
6) Vent/Drain Valve: One per sensing cavity.
7) Material: Sensing element components to be 316 stainless steel, or as shown on the instrument schedule.
8) Process Connection: 0.5 inch NPT, unless noted otherwise in the instrument schedule.
9) Electrical: 0.5 inch rigid conduit with screw terminals. Provide electrical protection against lightning.

10) Freeze Protection: If the transmitter and process piping are located outdoors, provide freezing protection for both.
11) Provide block and shutoff valves. Meet the following requirements:
    a) Size: 0.5 inch (1.0 inch for diaphragm seal installations).
    b) Type: Ball.
    c) Pressure: Up to 400 psi.
    d) Body:Brass or bronze, for non-corrosive atmosphere, PVC or epoxy coated for corrosive atmosphere.
    e) Seats and Seals:Teflon.
    f) Ball and Stem:Same material as sensing element.
    g) Provide:Gemini valve series 76, or equivalent
12) Differential pressure indicating transmitters shall be the same as the gauge pressure transmitter except for body specifications. Differential pressure units shall be furnished with close coupled stainless steel three valve manifold assembly. Manifold assembly shall be HEX Products Model HM, or equal. Overpressure limits shall be as scheduled.
13) Differential pressure transmitters shall have an integral square root extractor to provide a linear 4-20 mA flow signal output. In addition, each flow transmitter shall be furnished with laminated flow versus differential pressure curves wall mounted adjacent to the transmitter. Where scheduled, transmitters shall be furnished with remote diaphragm seals and 316 stainless steel sealed capillary tubes to isolate the transmitter from the process fluid.
14) Provide corrosive resistant mounting hardware for mounting the instrument. Unless otherwise shown on the instrument schedule, provide NEMA 4X enclosure, pipe mounted.
15) Provide differential pressure transmitters complete with a three-valve manifold Meet the following requirements:
    a) Materials:Same as block and shutoff valves.
    b) Process Connection: 0.5 inch NPT.
    c) Outlet Ports: 0.5 inch NPT.
    d) Purge Taps:0.5 inch NPT located between block valves and outlet ports.
16) Transmitter shall be as manufactured by Rosemount model 1151 smart, or approved equal.
17) INSTALLATION:
    a) Install the transmitter in an orientation where the sensing diaphragms are in a vertical plane.
    b) Allow sufficient clearance overhead for cover removal and around the transmitter to provide an access for necessary adjustments.
    c) Provide connections for drain and vent ports on the transmitter as per manufacturer's recommendations.
    d) Locate transmitters as close to the process pipe and pressure tap as practical with the lengths of meter lead piping/tubing kept to a minimum. Do not exceed 50 feet lead length. Locate the transmitter to minimize exposure to shock and vibration, or with proper vibration protection hardware and rugged frame. Select location to avoid any thermal shocks.

e) Slope horizontal leads a minimum of one inch per foot downward from the pressure taps for liquid and steam measurement.
f) Slope horizontal leads at least one inch per foot upward from the pressure taps for gas measurement,
g) Wrap Teflon tape on the external threads of screwed fittings.
h) Install differential pressure transmitters for flow measurement to insure that vertical leads on the high and low pressure sides are of equal length so as not to create an error in the measured signal.
i) Do not run horizontal meter leads in excess of six feet without supports.
j) Locate output indicators allow easy access for viewing and service by operations personnel.

C. P2. PRESSURE SWITCH
1. Type:
   a. Diaphragm actuated.
2. Functional/Performance:
   a. Repeatability - Better than 1.0 percent of pressure.
   b. Set Point - Field adjustable and set between 30 and 70 percent of the adjustable range.
   c. Deadband - shall be fixed unless noted otherwise on the Instrument Device Schedules.
   d. Reset - Unit shall be of the automatic reset type unless noted otherwise on the Instrument Device Schedules.
   e. Over-range Protection - Provide over-range protection to maximum process line pressure.
   f. Switch Rating - 250V AC at 10 amps; and 30V DC at 5 amps.
3. Physical:
   a. Housing - NEMA 4X.
   b. Switching Arrangement - Provide single pole double throw (SPDT) unless double pole double throw (DPDT) switches are shown on the instrument device schedule.
   c. Wetted Parts - Teflon coated diaphragm, viton seals, stainless steel connection port.
   d. Connection Size – 1/2-in NPT.
4. Accessories/Options Required:
   a. Shutoff Valve - Provide process shutoff valve which can be used as an adjustable pressure snubber.
5. Manufacturers:
   a. Ashcroft, Mercoid, Square D or Owner/Engineer approved equal.

D. P3. PRESSURE GAUGE OR PRESSURE INDICATOR
1. Type:
   a. Bourdon tube actuated pressure gauge.
   b. Absolute, gauge or differential pressure operation, as indicated on the loop drawings
2. Functional/Performance:
   a. Accuracy - Plus or minus 1.0 percent of span or better.

3. Physical:
   a. Case - Phenolic shock resistant or 316 stainless steel for surface/stem mounting with a pressure relieving back. The case shall be vented for temperature/atmospheric compensation. Gage shall be capable of being liquid filled in the field or at the factory.
   b. Window - Clear acrylic or shatter proof glass.
   c. Bourdon Tube - 316 stainless steel.
   d. Connection – 1/4-in NPT.
   e. Gage size - 4.0-in minimum, unless otherwise noted for small pipe connection in other specifications.
   f. Pointer travel - Not less than 200 degrees nor more than 270 degree arc.
   g. Range - As indicated in the instrument device schedule.
4. Accessories/Options Required:
   a. Shutoff valve - Each gage shall have a process shutoff valve which can also be used as an adjustable pressure snubber.
   b. Special scales - Engineer reserves the right to require special scales and/or calibration if the manufacturers standard is not suitable for the application.
   c. Gauges listed as liquid filled or to be provided with a diaphragm seal in the instrument device schedule shall be Glycerin filled with appropriate sealing barrier to prevent the process fluid from entering the gage. The liquid filled gauges shall be glycerin filled at the factory and the entire assembly shall be shipped complete from the factory.
   d. Test valve - Each gage shall have a test valve connected to a piping tee for testing of the unit when the process is isolated..
5. Manufacturers:
   a. Ashcroft
   b. Or Owner/Engineer Approved Equal.

E. W1. HYDRAULIC WEIGHT SCALE PLATFORM WITH DISPLAY DIAL AND 4-20MA SIGNAL
   1. Furnish and install low profile platform scales that shall be the hydraulic cell type. Scale shall be sized to accept tote from dimension of 50” x 50” minimum. Coordinate with tote supplier during bidding to confirm the dimension of tote and adjust accordingly. The low profile platform shall include an adjustable backstop to accommodate easy loading and unloading of chemical tote bins. Platform scale coating system shall be a minimum dry thickness of 80 mils and be resistant to moisture, chemicals, abrasion, impact and UV light.
   2. Load cell shall be of the temperature stable, rolling diaphragm type. A 5 ft. (meter) flexible length of tubing shall lead from the load cell to allow easy installation of the dial on the platform mounted dial stand. Load plate shall be able to tilt to 4 degrees without affecting accuracy to allow easy installation. Flexible hose shall lead from the load cell to allow easy remote installation of the dial and shall be 12ft minimum. Load cell system shall require no electric power and shall be immune to all RFI/EFI, power failures and lightening strikes.
   3. Dial diameter shall be 8-1/2" and read zero to XXX lbs. (kgs) with provision for tare adjustment. Dial shall be temperature stable with damper installed to prevent shock damage. Coordinate with process Engineer for tote capacity (lbs) and select appropriate platform capacity and model number.

4. Scale shall carry a minimum Five (5) Year Factory Warranty . "Limited" Warranties shall be considered unacceptable.
5. Scale shall have a SATELLITE® loop powered 4-20mA output proportional to gross weight.
6. Full scale accuracy shall be better than ½ of 1%. Scale shall be CHEM-SCALE™ TOTE BIN SCALE with TUF-COAT™ coating and hydraulic CENTURY® dial indicator, Model 50-12DXX-TB (where XX is capacity in lbs), as manufactured by FORCE FLOW, 2430 Stanwell Drive, Concord, CA 94520 USA (www.forceflow.com), or Owner/Engineer approved equal. Provide pipe stand support and mounting hardware for hydraulic CENTURY® dial indicator near each tote and mount approximately 4-feet above finished grade.

F. X1. Sunshade / Rain Hood:
1. Instrumentation suns shade shall be aluminum material for the application. Fiberglass sunshade is not acceptable. Furnish shade with appropriate 316 stainless steel mounting hardware as shown on Instrumentation Detail Drawing. Provide UV protective flexible sun shield in front of the transmitter display. Flexible sun shield cover shall be attached to the sunshade/ rain hood using door hinges and screws so that it can be easily flip over to read the instrument display.

2.09 CONTROL STRATEGY SCHEDULES

A. The control strategies are written descriptions of the programming required to implement regulatory and sequential control of the unit processes. Control strategies shall fully reside in the memory of the designated PLC. Coefficients pertaining to control strategies shall be modifiable through the operator interface in the monitoring / control mode. The PLC software programmer shall include an additional 80 hours on-site to fine tune control systems and make minor software modifications in order to resolve any logic discrepancies encountered during start-up, and supply the Owner with a complete functional system. This is part of the bid package with no additional cost to the Owner.

B. Existing BFP feed Pumps Control: BFP feed pumps and VFD (variable frequency drive) are existing and will remain. Contractor shall provide new BFP feed pump control strategy in the BFP master PLC system (PCP-DW) as needed and as describes in this specification. Existing BFP feed pump VFD units have LOCAL/REMOTE control selection. If LOCAL control is selected at the VFD unit, the unit can be started/stopped from the local START/STOP selector switch at each VFD panel. If REMOTE control is selected at the VFD unit, the PLC program will control the start/stop of each BFP feed pump. In the PLC program, the "AUTO/MANUAL" control selection shall be available from the SCADA screen for operator to select. In MANUAL mode, the Operator can start/stop the desired BFP feed pump from the SCADA screen. In AUTO mode, the PLC logic shall start/stop the appropriate BFP feed pump based on the automatic pump selection logic.

C. BFP feed Pump Automatic Pump Selection Logic: There are five existing BFP feed pumps and a minimum of one BFP feed pump will be needed for one BFP. The PLC logic shall rotate pump based on the total runtime if more than one pump is assigned to the same BFP unit. The PLC logic shall have a pump rotating matrix that can be assigned thru SCADA screens and the operator can easily take any pump “out of service” to remove from the rotation. BFP Feed pump VFD shall have flow setpoint (field adjustable) control and adjust the speed based on the associated flowmeter measurement.

D. The existing VFD unit of each BFP feed pump signals and control will be connected to the new BFP master panel (PCP-DW) as shown on drawings.

E. Each Belt Filter Press (BFP) unit shall require a permissive of “BFP feed Pump Running” signal based on the pump assignment. If more than one BFP feed pumps are assigned to one BFP unit, only one running signal permissive is needed.

F. Each BFP unit shall also need the associated horizontal conveyor, incline conveyor, and truck loading conveyor running signal permissive to operate. For If associated conveyor running signals are removed, associated BFP unit shall shutdown. For example, Horizontal conveyor No.1, Inclined conveyor No.1, and Truck Loading conveyor shall be running to start the BFP No.1 or No. 2 unit. Future Horizontal conveyor No.2, future Inclined conveyor No.2, and Truck Loading conveyor shall be running to start the future BFP No.3 and No.4 unit.

G. No sludge flow alarm: If BFP feed pump is running and no flow is registered at the associated flowmeter after 2 minutes (field adjustable), PLC shall send a “No Sludge Flow Alarm” to the plant SCADA system.

H. Individual BFP unit control will be programmed by the software programmer of the BFP’s supplier inside the BFP No.1 or No.2 Local control panel. BFP supplier’s software programmer may need some programming in the BFP master control panel and contractor shall coordinate with the software programmer of the BFP’s supplier for programming in the same PLC processor and avoiding duplicate address or tag, etc. Refer to specification 11362 for BFP Control Description.

I. <u>Polymer Tote weight scale:</u> If weight scale of polymer tote is below 10% (field adjustable from HMI/SCADA), the PLC program shall send an alarm to the Plant PLC/HMI system for “Polymer Tote No.X low alarm”.

J. TSS meter selection: PLC program shall have TSS meter selection to control the BFP feed pump speed and shall be selectable from the SCADA/HMI screen. Existing TSS meters are connected to the existing PCP-2 panel in Electrical Building No.2 and shall message between PLC system to obtain the measurement. PLC logic shall have TSS meter selection logic and allow operator to select from the SCADA/HMI screens. Selection choices shall be “TSS meter at Distribution Box No.2”, “TSS meter at Distribution Box No.3”, or “average TSS value”.

K. Miscellaneous Control and Monitoring: In addition to process monitoring and control shown on Instrumentation drawings, the reclaimed PLC shall control and/or monitor the following station attributes:
   1. <u>Pump Ready</u>: When pump is in Auto and no fault alarm, the PLC logic shall generate “pump ready” signal.

2. Pump Failed to Start: When the pump is called to start and within a preset adjustable time (10 seconds), no running feedback is received, the PLC logic shall generate “pump failed to start” alarm.
3. Total Run Time: The PLC program shall have a counter for total run time for each pump and display on SCADA/HMI screens.
4. Analog Input (flow, pressure, etc.): The PLC program shall have the “Hi-Hi”, “High”, “Low”, and “Low-Low” alarms set point (adjustable) for all analog inputs and generates the “Hi-Hi”, “High”, “Low”, and “Low-Low” alarms if the condition occurs. All alarms shall be auto reset when alarm condition goes away.
5. Auto-Manual Start-Stop scheme for all equipment (pump or valves) shall operate on the following way: Any equipment shall have Auto and Manual mode selectable from the HMI screen. In Auto mode the particular pump or valve shall follow the auto control strategy described above. In Manual mode, operator shall be able to Start, Stop, Open or Close pump/ Valve from the HMI screen. VFD pump or modulating valve shall have in addition the manual set point for speed/ position.
6. The control system shall be designed to allow online calibration and repair of instruments used in the plant control scheme without disruption of the plant process or production rate. This shall be accomplished using operator selectable process hold values in conjunction with operator selectable hold timers and alarms to remind operators to reset the system to active inputs.
7. All alarms that are generated by the PLC and have active role in PLC logic, shall be latched, and shall be resettable from the HMI screens, except the alarms that need to be reset on the field.
8. All alarms generated by the PLC shall have selectable value in HMI for alarm set point, and selectable time delay.
9. 9. All Set points for PID loops shall be enterable from the screen together with percentage that PLC shall use to calculate stage up and stage down set points. That calculation shall be one scan operation. After that one scan operation initiated by either entering the PID set point or percentage, operator shall be able to overwrite calculated values from the screen

2.10 PROGRAMMING SOFTWARE

A. No new PLC software license is needed as part of this project. Contractor shall use own software to program the PLC system and the SCADA system.

2.11 TOUCH SCREEN HUMAN-MACHINE INTERFACE (HMI)

A. General:
   1. 1 Function: Allows operator to monitor and control at DPC/PLC level.
   2. Type: Allen-Bradley Panelview plus 7 touch screen. Match with Belt Filter Press Local Control Panel HMI touch screen model.
   3. Parts: Touch screen, power and communication cabling, communication module, accessories.

B. Environmental:
   1. Operator Temperature: 0 to 55 degree C.
   2. Humidity: 5 to 95% (without condensation) @ 0 to 55 degree C.
   3. Storage Temperature: -25 to 70 degree C.

C. Features:
1. Display Type: TFT liquid crystal display (LCD), 256 colors.
2. Display size:12.0 x 9.0” (1024X768 pixels).
3. Display Panel size; 10.4”
4. Application Memory: 7168K user memory; 5689K for options. Alarm Buffer. Provide memory flash card for storage for backup.
5. Power Requirements: 85 to 264 Vac
6. Power Consumption: 200VA max.
7. Certifications: UL approved.
8. Vector graphic capable.

D. Interfaces:
1. Ethernet.

E. Accessories:
1. Configuration Software and Ancillaries:
   a. Latest Version of Rockwell Automation RSView software – Factory Talk View Machine Edition or equal. Provide software license for HMI touch screen, if needed. Software license shall be provided for City of Daytona Beach – Westside Regional Water Reclamation Facility and shall have full development license so that Owner can modify the screen in the future.
   b. Full documentation.
   c. Download cable.
   d. Power Cords.
2. Alarms: 4000 Alarms/32 classes.
3. Up to 500 process screens.
4. 2048 process tags.
5. Bar graphs/trend curves.
6. Screen blocks.
7. Recipes: up to 500 total.

2.12 INSTRUMENT LIST

TAG NO.	COMPONENT CODE	COMPONENT TITLE	COMPONENT OPTIONS	REMARKS
WI/WT-TK-PL01	W1	POLYMER STORAGE TOTE NO.1 WEIGHT	0-2500 lbs	
WI/WT-TK-PL02	W1	POLYMER STORAGE TOTE NO.2 WEIGHT	0-2500 lbs	
FE-WW01/ FIT-WW01	F1	BFP NO.1 WASHWATER FLOW	0-300 gpm	2” Diameter.
FE-WW02/ FIT-WW02	F1	BFP NO.2 WASHWATER FLOW	0-300 gpm	2” Diameter.
PIT-WW01	P1	BFP NO.1 WASHWATER PRESSURE	0-200 PSIG	
PIT-WW02	P1	BFP NO.2 WASHWATER PRESSURE	0-200 PSIG	

TAG NO.	COMPONENT CODE	COMPONENT TITLE	COMPONENT OPTIONS	REMARKS
Provide one spare pressure transmitter (Component Code: P1) – matching the model supplied.				

PART 3 EXECUTION

3.01 INSTALLATION, CALIBRATION, TESTING, START-UP AND INSTRUCTION

A. GENERAL:
1. Under the supervision of the Single I&C supplier, all systems specified in this Section shall be installed, connected, calibrated, and tested, and in coordination with the Engineer and the Owner, shall be started to place the processes in operation. This shall include final calibration in concert with equipment specified elsewhere in these Specifications, including pumps, valves, as well as certain existing equipment.

B. Testing
1. All systems shall be exercised through operational tests in the presence of the Engineer in order to demonstrate achievement of the specified performance. Operational tests depend upon completion of work specified elsewhere in these Specifications. The scheduling of tests shall be coordinated by the Contractor among all parties involved so that the tests may proceed without delays or disruption by incomplete work.
   a. Unwitnessed Factory Test (UFT):
      1) An unwitnessed factory test shall be conducted to prepare the I&C Supplier to demonstrate compliance with this specification.
      2) The I&C Supplier shall inspect and test the Integrated Control System (ICS). This test shall take place at the I&C Supplier's factory. It shall consist of interconnecting computers, PLC control panels, communications links, and other new Control Panels (unless specifically excluded below)
      3) All primary element inputs shall be simulated (inputs shall be adjustable by switch, if discrete; by potentiometer or similar device, if analog). Primary outputs shall be monitored via output devices (pilot lights, for discrete; a meter, digital display (12-bit min. resolution) or other such analog device, if analog output).
      4) Excluded New Panels: None
   b. Factory Acceptance Test (FAT):
      1) Not used.

C. INSTALLATION AND CONNECTION:
1. The Contractor shall install and connect all field-mounted components and assemblies under the criteria imposed in Part 1, 1.03, herein. The installation personnel shall be provided with a final reviewed copy of the Shop Drawings and data.
2. The instrument process sensing lines and air signal tubing shall, in general, be installed in a similar manner to the installation of conduit specified under Section 16050. Individual tubes shall be run parallel and near the surfaces from which they are supported.
   a. Supports shall be used at intervals of not more than 3 feet of rigid tubing.

b. Bends shall be formed with the proper tool and to uniform radii and shall be made without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at all panels.

3. The Contractor shall have a technical field representative of the I&C supplier to instruct these installation personnel on any and all installation requirements; thereafter, the technical field representative shall be readily available by telephone to answer questions and supply clarification when needed by the installation personnel.
   a. Where primary elements (supplied by I&C supplier) shall be part of a mechanical system, the I&C supplier shall coordinate the installation of the primary elements with the mechanical system manufacturer.
4. Fiber optic cable shall be furnished by the I&C Supplier and installed by the Electrical Contractor. The I&C Supplier shall provide the services of an experienced fiber optic cable terminator and tester. The I&C Supplier shall supervise the cable installation and shall carry out all terminations at the I/O racks, repeaters, and data concentrators at PLC's and computers. Fiber optic cable termination shall be carried out using the appropriate connectors and termination kit. All fiber optic system components shall be products of one manufacturer.
   a. Fiber optic cable system shall be designed to minimize cable splicing. Where splicing becomes necessary perform fusion splice with loss not to exceed 0.2 dB. Test all splices with an Optical Time Domain Reflectometer (ODTR) bi-directionally to verify splice loss at the time of splicing. Redo any splices not conforming to Specifications. Provide means to protect the unspliced portions of the cable from intrusion of moisture and other foreign matter. Identify required splices in the submittal. Splices not identified in the submittal shall not be acceptable unless approved by the Engineer.
   b. After the fiber optic data link is in place, test the attenuation from hub to hub bi-directionally and document test results. Attenuation in excess of 3.5 dB/km at 850 nm wavelength or 1.0 dB/km at 1300 nm wavelength shall require the I&C supplier to replace the defective sections and retest until the attenuation is below the attenuation allowed per kilometer at the wavelengths cited.
   c. The I&C Supplier is responsible for the satisfactory performance of all fiber optic data links. Demonstrate and document error free bi-directional data files transfer from each host computer to each PLC node.

5. Finally, after all installation and connection work has been completed, the technical field representative shall check it all for correctness, verifying polarity of electric power and signal connections, making sure all process connections are free of leaks, and all such similar details. If the initial inspection finds no deficiencies, the technical field representative shall proceed to the certification to the Contractor. Any completed work that is found to have deficiencies shall have those deficiencies corrected by installation personnel at no additional cost to the Owner. The technical field representative shall then recheck the work after the identified deficiencies are corrected. If the technical field representative finds deficiencies in the follow-up inspection, then remedial action shall be taken by the Contractor at no cost to the Owner. This pattern shall be repeated until the installation is free from defect. The technical field representative shall then certify in writing to the Contractor that for each loop or system that he has inspected is complete and without discrepancies.
6. The field representative of the Single I&C supplier shall coordinate all work required to interface the new equipment and control devices with the existing equipment, including all required modifications to existing equipment and related devices.

D. Calibration

1. All instruments and systems shall be calibrated after installation, in conformance with the component manufacturer's written instructions. This shall provide that those components having adjustable features are set carefully for the specific conditions and applications of this installation, and that the components and/or systems are within the specified limits of accuracy. Defective elements which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced. This calibration work shall be accomplished by the technical field representatives of the I&C system supplier who shall certify in writing to the Contractor that for each loop or system all calibrations have been made and that all instruments are ready to operate. See Article 3.02 supplements for sample "Instrumentation Calibration Sheet".

E. PRE-COMMISSIONING

1. The I&C Supplier shall test each loop (discrete and analog) to determine if it is functioning correctly. The I&C Supplier shall furnish a loop sheet for each loop to be tested. The loop sheet shall represent the actual “as-built” condition of the loop. The I&C Supplier shall perform a field functional loop test which shall be witnessed by the Engineer and Owner. If the loop fails the functional test, the I&C Supplier shall coordinate repairs for the Contractor to correct whatever is wrong with the loop. The I&C Supplier shall retest the loop until it is approved.
2. Each loop shall be tested and approved by Engineer and Owner until all loops have been approved.

F. Start-up and Instruction
   1. When all systems are assessed by the Contractor to have been successfully carried through complete operational tests with a minimum of simulation, and the Engineer concurs in this assessment, plant start-up by the Owner's operating personnel can follow. For a minimum of three times for (4) hours prior to start-up, operating and maintenance personnel shall be instructed in the functions and operation of each system and shall be shown the various adjustable and set point features which may require readjustment, resetting or checking, re-calibration or maintenance by them from time to time. This instruction shall be scheduled at a time arranged with the Owner at least two (2) weeks in advance. Instruction shall be given by qualified persons who have been made familiar in advance with the systems. All equipment shall be checked during the first year of operation at intervals of three months for a period of not less than one day or as may be required to correct any defects to the satisfaction of the Owner.

G. Modifications to Existing Facilities
   1. The Contractor shall make all modifications to existing equipment and control devices which are required to successfully install and integrate all new instrumentation equipment. All costs for any required modification and rehabilitation effort shall be included in the Contractor's original bid amount and no additional payment shall be allowed.

H. Plant Shutdowns
   1. The Single I&C supplier shall carefully examine all work to be performed relative to existing I&C equipment and the installation of new equipment and control devices. Work shall be scheduled to minimize required plant shutdown times.

I. Coordination with Other Concurrent Projects
   1. The single I&C supplier shall coordinate extensively with other I&C suppliers of concurrent projects. Some of the equipment shown in this contract as existing might be installed while this contract is underway.

3.02 SUPPLEMENTS

A. Supplements listed below, following "END OF SECTION," are part of this Specification.
   1. Loop Status Report.
   2. Functional Acceptance Test Sheet.
   3. Instrumentation Calibration Sheet.

END OF SECTION

LOOP STATUS REPORT

PROJECT NAME: ________________________

PROJECT NO.:__________________________

FUNCTIONAL REQUIREMENTS

			COMPONENT	**STATUS**		
TAG NO.	DELIVERED*	TAG/IDENTIFI-CATION CHECK*	INSTALLATION CHECK	TERMINATION WIRING*	TERMINATION TUBING*	CALIBRATED*
REMARKS				LOOP READY FOR START-UP		
				BY		
				DATE		

* INITIAL AND DATE WHEN COMPLETE

FUNCTIONAL ACCEPTANCE TEST SHEET

PROJECT NAME: ________________________
PROJECT NO.: ___________________________

FUNCTIONAL REQUIREMENTS AND SUMMARY OF COMPONENTS: (ATTACH XEROX OF LOOP SPECIFICATION FROM THE CONTRACT DOCUMENTS)
VERIFICATION OF LOOP STATUS REPORT AND BY:____________________________ INSTRUMENT AND VALVE CALIBRATION SHEETS DATE:____________________________
DEMONSTRATION TEST(S): FOR EACH FUNCTIONAL REQUIREMENT OF THE LOOP: REQUIRED PERFORMANCE (a) LIST AND NUMBER THE REQUIREMENT (c) CITE THE RESULTS THAT WILL VERIFY THE (b) BRIEFLY DESCRIBE THE DEMONSTRATION (d) PROVIDE SPACES FOR INITIAL AND DATE OF TEST TEST WITNESS.

PERFORMED BY: WITNESSED BY: COMPLETED DATE:	LOOP ACCEPTED BY (OWNER) BY DATE
CHECK IF REMARKS ON REVERSE SIDE	LOOP NO.

INSTRUMENTATION CALIBRATION SHEET

<table>
<tr><td colspan="14"></td></tr>
<tr><td colspan="5">COMPONENT
CODE:

NAME:</td><td colspan="4">MANUFACTURER:
MODEL:
SERIAL:</td><td colspan="5">PROJECT
NUMBER:
NAME:</td></tr>
<tr><td colspan="5">RANGE VALUE UNITS
☐INDIATE/ CHART ______ ______
RECORD
SCALE ______ ______
☐TRANS/ INPUT ______ ______
CONVERT
OUTPUT ______ ______</td><td colspan="4">☐ COMPUTE
FUNCTIONS</td><td colspan="5">☐ CONTROL
ACTION (DIRECT/REVERSE)
MODES (P/I/D)

☐ SWITCH
UNIT RANGE (VALUE/UNITS)
DIFFERENTIAL (FIXED/ADJUSTABLE)
RESET (AUTOMATIC/MANUAL)</td></tr>
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<tr><td colspan="3">REQUIRED</td><td colspan="4">AS CALIBRATED</td><td colspan="3">REQUIRED</td><td colspan="2">AS CALIBRATED</td><td rowspan="2">REMARKS

CODE</td></tr>
<tr><td>IN</td><td>SCALE</td><td>OUT</td><td>SCALE</td><td>OUT</td><td>SCALE</td><td>OUT</td><td>NUMBER</td><td>TRIP PT</td><td>RESET PT</td><td>TRIP PT</td><td>RESET PT</td></tr>
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<tr><td colspan="7">C. MODE SETTINGS: P I D</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3"></td><td colspan="10"></td><td colspan="3" rowspan="2">COMPONENT CALIBRATED AND READY FOR START-UP
BY
DATE</td></tr>
<tr><td colspan="10"></td></tr>
<tr><td colspan="10"></td><td colspan="3">TAG NO.</td></tr>
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