

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. Concrete anchors and bolts for attachment of guard baseplates to supporting members shall conform to Section 05050– Metal Fastening.
- G. All fabricated items shall be shop painted in accordance with Section 09900 – Painting.

3.02 INSTALLATION

- A. Assembly and installation of guards and railings shall be performed in strict accordance with manufacturer's recommendations.
- B. All guards and railings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

- END OF SECTION -

SECTION 05531

GRATINGS, CHECKERED FLOOR PLATES, AND ACCESS DOORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all gratings, floor plates, and access doors in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05010 – Metal Materials
- B. Section 05050 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. Florida Building Code
 - 2. Aluminum Association Specifications for Aluminum Structures
 - 3. Occupational Safety and Health Administration (OSHA) Regulations
 - 4. ANSI/NAAMM MBG 531 – NAAMM Metal Bar Grating Manual
 - 5. ASTM C1802 – Design, Testing, Manufacture, Selection, and Installation of Fabricated Metal Access Hatches for Utility, Water, and Wastewater Structures

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01300 – Submittals.
 - 1. Complete fabrication and erection Drawings of all gratings, floor plates, and access doors specified herein.
 - 2. For checkered floor plates, structural calculations signed and sealed by a currently registered Professional Engineer in the State of Florida verifying the proposed floor plate meets the minimum load and deflection requirements stipulated herein.

3. For access doors provided by a manufacturer not specifically named herein, structural calculations signed and sealed by a Professional Engineer currently registered in the State of Florida verifying the proposed access door meets the minimum load and deflection requirements stipulated herein. For access doors provided by a named manufacturer, sealed calculations are not required provided the applicable ASTM C1802 load rating is clearly indicated in the submittal for each proposed product.
4. Other submittals as required in accordance with Section 05100 – Metal Materials and Section 05050 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for gratings, floor plates, and access doors shall conform to Section 05100 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for gratings, floor plates, and access doors shall conform to Section 05050 – Metal Fastening, unless noted otherwise.

2.03 GRATING

- A. General - Grating, including support frames, fastenings, and all necessary appurtenances for a complete installation, shall be furnished as indicated on the Drawings.
 1. All exposed bearing ends of grating shall be enclosed in a perimeter band of the same dimensions and material as the main bars, including ends at all cutouts.
 2. Grating shall be fabricated into easily removable sections and shall be fastened at each corner and as required with fasteners provided by the grating manufacturer. No fasteners shall be permitted to project above the walking surface.
 3. Grating shall be designed for a loading of 150 psf unless otherwise required by the Drawings. Grating deflection shall not exceed 1/4 inch under a uniform load of 150 psf. Minimum grating depth shall be 1-1/2 inches, unless structural requirements based on clear span require more depth.
 4. Grating installed in cast-in-place concrete shall be provided with embedded support frames on all perimeter and bearing edges. Support frames shall be extruded frames with continuous means of anchoring frames to concrete around entire perimeter of frame. Support frames shall be fabricated from the same material as the grating.

B. Aluminum Grating

1. Aluminum grating shall be of I-bar type and shall consist of extruded bearing bars positioned and locked by crossbars. All supports, cross members, etc. shall be aluminum. Plank clips for grating attachment to frames and any other required attachments, shall be aluminum or stainless steel. Bolts shall be stainless steel. Provide embedded aluminum support frames for cast-in-place concrete installations.
2. Grating shall be "IB" by Harsco Industrial IKG, "I-Bar 19SGI4", by Ohio Grating Inc., or "I-Bar" by Thompson Fabricating LLC.

2.04 CHECKERED FLOOR PLATES

- A. Floor plates shall meet the requirements of ASTM C1802 for Load Level 1 – Light Pedestrian Load, minimum, unless otherwise indicated on the Drawings.
- B. Floor plates shall be aluminum unless noted otherwise.
- C. All floor plates shall be checkered plate with an approved raised pattern, non-skid surface.
- D. Openings greater than 42 inches in either direction shall require two plates opening via hinges in opposite directions.
- E. Floor plates shall be designed to carry a minimum service level live load of 300 psf, or a concentrated load of 600 pounds applied over a 5.50 inch by 5.50 inch area, whichever produces the greatest stress, unless indicated otherwise on the Drawings. Loading shall be positioned to produce the greatest stresses, both due to maximum moment and maximum shear load conditions.
- F. All components of checkered floor plates shall have a minimum tensile yield strength of 23,000 psi and a minimum compressive yield strength of 21,000 psi. Yield strengths shall be indicated on both the structural calculations and the fabrication drawings.
- G. Live load deflection shall be limited to $L/200$ of the span, but no greater than 3/16 inch.
- H. All checkered floor plates shall be fabricated from 3/8" plate, minimum and shall be stiffened as required to maintain allowable stress and deflection requirements specified herein.
- I. Stiffeners shall consist of angles or bars welded to the bottom of the plate.
- J. Checkered floor plate hinges shall be either stainless steel or aluminum with stainless steel pins and fasteners.
- K. All checkered floor plates shall be provided with recessed handles. Handle material shall be as shown on the Contract Drawings.

- L. Air-tight and water-tight checkered floor plates shall be provided with a 1/8-inch-thick neoprene gasket between the checkered plate and the support frame. Gasket material shall be bonded to the support frame and checkered floor plates shall be bolted to the structural support frame with countersunk stainless-steel flathead screws.
- M. All floor plates shall be clearly marked with the information listed below. Markings shall be indicated on metal or plastic tags permanently attached to the floor plate or frame or shall be permanently painted or printed.
 - 1. The manufacturer's name or trademark, location, and telephone contact number.
 - 2. The manufacturer's model number and ASTM designation.
 - 3. The design load level as indicated in ASTM C1802. If the design requires deviation from the Load Level requirements specified in ASTM C1802, a description of the modifications shall be included.
 - 4. Date of manufacture and/or serial number.

2.05 ACCESS DOORS

A. General

- 1. Door opening sizes, number, and direction of swing of door leaves, and locations shall be as shown on the Drawings. The Drawings shall indicate the dimensions of the openings in the concrete. Clear opening dimensions shall be no smaller than six inches less than the concrete opening.
- 2. All doors shall be aluminum unless otherwise noted.
- 3. All door components shall have a minimum tensile yield strength of 23,000 psi and a minimum compressive yield strength of 21,000 psi. Yield strengths shall be indicated on both the structural calculations and the fabrication drawings.
- 4. Openings larger than 42 inches in either direction shall have double leaf doors.
- 5. Doors shall be designed for flush mounting and for easy opening from both inside and outside.
- 6. All doors shall be provided with an automatic hold-open arm with release handle.
- 7. Double leaf doors shall be provided with safety bars to go across the open sides of the door, when in the open position. Brackets shall be provided on the underside of the doors to hold the safety bars when not in use.
- 8. All hardware, including but not limited to, all parts of the latch and lifting mechanism assemblies, hold open arms and guides, brackets, hinges, springs, pins, and fasteners shall be stainless steel.

9. All doors specifically required to be watertight shall be installed with a continuous gasket.
10. Access door frames with integral gutter systems shall be equipped with a 1-1/2-inch minimum drainpipe located by the manufacturer. The drainpipe shall be provided by the Contractor and shall extend to the nearest point of discharge acceptable to the Engineer.
11. All doors shall be clearly marked with the information listed below. Markings shall be indicated on metal or plastic tags permanently attached to the door or frame or shall be permanently painted or printed.
 - a. The manufacturer's name or trademark, location, and telephone contact number.
 - b. The manufacturer's model number and ASTM designation.
 - c. The design load level as indicated in ASTM C1802. If the design requires deviation from the Load Level requirements specified in ASTM C1802, a description of the modifications shall be included.
 - d. The nominal door opening dimensions and/or the manufacturer's model number.
 - e. Date of manufacture and/or serial number.

B. Floor, Wet Well and Dry Pit Access Doors

1. Door leaves shall be 1/4 inch, minimum, diamond pattern plate with an approved raised pattern, non-skid surface. Plate shall be stiffened as required to maintain allowable stress and deflection requirements. Stiffeners shall consist of angles or bars welded to the bottom of plate.
2. Doors shall be designed for flush mounting and for easy opening from both inside and outside.
3. All doors shall have an enclosed compression spring assist and open to 90 degrees.
4. Doors not required to support traffic loading shall meet the requirements of ASTM C1802 for Load Level 2 – Pedestrian Load as a minimum and the following:
 - a. Doors shall be designed to carry a minimum service level live load of 300 psf or a concentrated load of 600 pounds applied over a 5.50 inch by 5.50 inch area, whichever produces the greatest stress, unless indicated otherwise on the Drawings. Loading shall be positioned to produce the maximum stresses, both due to maximum moment and maximum shear load conditions.

- b. Live load deflection shall be limited to L/200 of the span, but not greater than 3/16 inch.
- c. Unless otherwise noted, exterior doors shall have an integral gutter system and be Type "FDDP" by Nystrom, Type "W1S" or "W2S" by Halliday Products Inc., Type "TPS" or "TPD", by U.S.F. Fabrication Inc., or Type "THG" or "THG-D", by Thompson Fabricating LLC, or Type "J-AL" or "JD_AL" by the Bilco Company.
- d. Unless otherwise noted, interior doors shall be Type "FDNP" by Nystrom, Type "S1S" or "S2S" by Halliday Products Inc., Type "APS300" or "APD300", by U.S.F. Fabrication Inc., or Type "TH" or "TH-D", by Thompson Fabricating LLC.

2.06 FALL THROUGH PREVENTION SYSTEM

- A. All checkered floor plates and access doors covering openings measuring 12 inches or more in its least dimension through which persons may fall shall be equipped with a fall through prevention system, except as noted on the Contract Drawings. Checkered floor plates and access doors shall be provided with a permanent installed fall through prevention grate system that provides continuous safety assurance in both its closed and open positions. The grate system shall be made with 6061-T6 aluminum or FRP and be designed for a 300 psf minimum live load, unless noted otherwise.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050 – Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All gratings, checkered floor plates, and access doors shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions. Embedded support frames shall be set level and square.
- C. Where access doors utilize leveling bolts, or are placed on irregular surfaces, and are not to be embedded in concrete, the area beneath the frames shall be fully grouted with non-shrink grout to create a uniformly loaded bearing surface.
- D. Grating shall not be field cut or modified unless approved by Engineer.
- E. Grating shall not be used for equipment support or anchorage.

- END OF SECTION -

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SECTION 05550

STAIR TREADS AND NOSINGS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all stair treads and nosings in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05010 – Metal Materials
- B. Section 05050 – Metal Fastening
- C. Section 05510 – Metal Stairs

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

- 1. 2023 Florida Building Code, 8th Edition
- 2. Aluminum Association Specifications for Aluminum Structures.

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01300 – Submittals.
 - 1. Complete fabrication and erection drawings of all work specified herein.
 - 2. Other submittals as required in accordance with Section 05010 – Metal Materials and Section 05050 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for stair treads and nosings shall conform to Section 05010 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for stair treads and nosings shall conform to Section 05050 – Metal Fastening, unless noted otherwise.

2.03 SAFETY STAIR NOSINGS

- A. Abrasive cast aluminum, safety stair nosings shall be provided on all concrete or concrete filled steel pan stairs, including the top stair of metal stairs that attach to concrete, and as shown on the Drawings unless noted otherwise.
- B. Nosing shall be 3 inches wide and shall extend the full width of the stairway minus 3 inches on either side. Nosing shall be cast into the concrete and held in place with butterfly type extruded anchors.
- C. The nosing shall be "Style 231-A", by Amstep Products, "Alumogrit Type 101", by Wooster Products, Inc., "Type AX", by Safe-T-Metal Company. For steel pan concrete filled stairs, nosing shall be "Type 101-SP", Wooster Products, Inc., or "Type AXPE", by Safe-T-Metal Company. For pan stairs, nosing shall be continuous over corner of stair treads to fully protect corner of treads from abrasion. All exposed fasteners shall be Type 304 stainless steel.

2.04 STAIR TREADS

- A. Stair treads shall be aluminum with an abrasive nosing as shown on the Drawings.
- B. Stair treads shall be designed for the live load specified in Section 05510 – Metal Stairs.
- C. Stair treads shall be as manufactured by IKG Industries, or Safe-T-Metal Company.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, connections, brackets, and other details necessary for a complete installation shall be provided.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

- D. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- E. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050 – Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

- A. Assembly and installation of stair treads and nosings shall be performed in strict accordance with manufacturer's recommendations.
- B. All stair treads and nosings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

- END OF SECTION -

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SECTION 07150

DAMPPROOFING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of work as shown on Drawings and specified herein.
- B. Principal items of work include:
 - 1. Dampproofing on exterior side of interior wythe of masonry cavity walls above grade.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04200 - Unit Masonry

1.03 REFERENCE SPECIFICATIONS CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM D 449 Standard Specification for Asphalt Used in Dampproofing and Waterproofing

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the Section 01300, Submittals, submit the following:
 - 1. Manufacturers product literature, specification data sheets and installation instructions.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in manufacturer's unopened containers identified with name, brand, type, grade, class and all other qualifying information.
- B. Store materials in dry location to prevent damage or intrusion of foreign matter. Remove damaged materials from the job site.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject with compliance with the Specifications provide products from one of the following:
 - 1. Karnak Corp.
 - 2. W.R. Meadows
 - 3. Koch Materials Co.

2.02 MATERIALS

- A. Asphalt Primer: Type recommended by manufacturer.
- B. Dampproofing: Non-asbestos, fibrated mastic conforming to ASTM D-1227, Type II, Class 1, compatible with cavity wall insulation.

PART 3 -- EXECUTION

3.01 EXAMINATION OF SURFACES

- A. Examine all surfaces and installation of work done by other trades.

3.02 APPLICATION

- A. Prime surfaces with manufacturers recommended primer. Apply dampproofing at the rate of 6 gallons per 100 square feet.
- B. Apply dampproofing to substrates to provide a complete moisture resistant coating.

3.03 PROTECTION

- A. Protect building from damage resulting from spillage, dripping and dropping of materials. Repair work damaged during dampproofing operations.
- B. Take precautions against fire and other hazards during delivery, storage and installation of flammable materials. Comply with local ordinances and fire regulations in the installation of hazardous materials.

3.04 CLEANING

- A. Clean adjacent materials and finishes which have been soiled.

- END OF SECTION -

SECTION 07185

MASONRY WATER REPELLANT COATING

PART 1 – GENERAL

1.01 SCOPE

- A. This section covers the water repellent coating for exterior surfaces of masonry block.

1.02 GENERAL

- A. The water repellent coating shall be delivered in unopened containers, labeled with the manufacturer's name, and shall be applied in accordance with the manufacturer's recommendations.

1.03 SUBMITTALS

- A. Complete specifications covering the materials furnished under this section shall be submitted in accordance with the Submittals Procedures section.

Data verifying that the applicator has been trained and licensed by the manufacturer of the water repellent coating shall also be submitted.

1.04 WARRANTY

- A. The water repellent coating shall have a 5 year written warranty against moisture penetration through the treated areas.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Water Repellent

- 1. The water repellent coating shall be Rainguard "Blok- Lok" as manufactured by Rainguard International, Conyers, Georgia or approved equal.

B. Standards

- 1. The water repellent coating shall meet the following;
 - ASTM E 514 – Wind Driven Rain, 98.7% leak reduction
 - ASTM C140-75 – Water Absorption, minimum 89% effective
 - ASTM C67 – Water Repellency, minimum 97% effective
 - ASTM G-53 – Weathering, minimum 2500 hours, no change
 - SS-W-110C – Water Pen Fed Spec, minimum 75% required

PART 3 – EXECUTION

3.01 SUBSURFACE PREPARATION

- A. New masonry shall be allowed to cure for 30 days prior to application of the coating, and moisture content on any surface shall not exceed 15 percent as registered on an electronic moisture meter.
- B. The surfaces to which the water repellent coating is to be applied shall be clean and dry. All dirt, grease, asphalt, tar, stains, clinging mortar, efflorescence, and contamination of every kind shall be removed by suitable methods.
- C. All cracks shall be neatly filled and pointed; the pointing mortar shall be allowed to cure and become dry and hard before the water repellent coating is applied. All joints shall be tight and sound.

3.02 APPLICATION

- A. All exterior masonry shall be sealed with water repellent coating applied by experienced, fully trained applicators licensed by the manufacturer of the coating.
- B. The water repellent coating shall be applied in two coats minimum. Additional coats as recommended by the manufacturer. 48 hours shall be allowed between coats, unless otherwise recommended by the manufacturer. Sufficient coats shall be applied to achieve a consistent and uniform appearance.
- C. The water repellent coating shall be applied with airless spraying equipment using low pressure and tip sizes as recommended. The coating shall be applied as a flood coat as recommended by the manufacturer.
- D. Care shall be taken to shield all surfaces that are not to be covered with the water repellent coating. Any such surfaces which are contaminated shall be immediately and thoroughly cleaned.

- END OF SECTION -

SECTION 07190

VAPOR BARRIER

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install a vapor barrier to be placed under all reinforced concrete placed against soil as specified herein or shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03300 - Cast-in-Place Concrete

PART 2 -- PRODUCTS

2.01 VAPOR BARRIER

- A. Vapor Barrier: A reinforced laminate membrane with a minimum tensile strength of 75 lbs/in. in accordance with ASTM D-882, vapor transmission rating of 0.02 perms in accordance with E-96, and a puncture resistance of 25 lbs in accordance with ASTM D-4833.
- B. Adhesive/Tape: Type approved by the Manufacturer of the vapor material.
- C. Penetration sealing: Provide manufacturer's recommended penetration seals at all pipe, conduit, and similar penetrations.

2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
 - 1. Viper Vapercheck 10 by Insulation Solutions, Inc.
 - 2. Griffolyn Type-85, by Reef Industries, Inc.
 - 3. Or Equal

PART 3 -- EXECUTION

3.01 VAPOR BARRIER

- A. Vapor barrier shall be placed on top of 4 inches minimum of compacted structural fill stone, free of debris and protrusions, as shown on the Drawings for structural slabs.

- B. Lap edges 12 inches and seal with adhesive tape. Lay with seams perpendicular to and lapped in the direction of placement. Do not penetrate vapor barrier.
- C. Protect from damage until concrete is placed. Punctures and tears in vapor barrier shall be repaired using patches of the material which overlaps puncture or tear a minimum of 12 inches; seal with tape or adhesive.
- D. Penetrations through vapor barrier, such as pipe, drains, conduits and similar penetrations, shall be sealed in strict accordance with manufacturer's recommended instructions.

- END OF SECTION -

SECTION 07510

BUILT-UP BITUMINOUS ROOFING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of Work shown on Drawings and specified herein.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM D41 Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
 - 2. ASTM D312 Asphalt Used in Roofing.
 - 3. ASTM D2178 Asphalt Felt Used in Roofing and Waterproofing.
 - 4. FS HH-I-1972/GEN Insulation Board, Thermal, Faced, Polyurethane or Polyisocyanurate.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01300, Submittals, submit the following:
 - 1. Product data for glass fiber ply sheet, modified bitumen sheet membrane, insulation and base flashing materials.
 - 2. Manufacturer's installation instructions.
 - 3. Certification that materials meet or exceed specified requirements.
 - 4. Certification that installer is approved by the manufacturer.
 - 5. Copy of manufacturer's 20 year system warranty.
 - 6. Samples of each product.
 - 7. Color samples of cap sheet.
 - 8. Field report at the end of all roofing and related work.

1.04 QUALITY ASSURANCE

- A. Applicator: Company well experienced in modified bitumen roofing membrane application and approved by product manufacturer.
- B. Products and installation shall be in accordance with the following:
 - 1. Underwriters Laboratories, Inc. (UL): Class A Fire Hazard Classification.
 - 2. Factory Mutual Engineering Corporation (FM): Roof assembly classification, FMRC, Approval Standard 4470, Class I, and I-90 approvals.
 - 3. Design roof to meet wind design criteria in the Florida Building Code 8th Edition.
- C. Field Report: After all work has been completed, including setting of roof top equipment, and other work required on the roof, provide a report from a Professional Engineering firm or manufacturer's representative verifying watertight and quality installation conforming to all warranty conditions. Report shall include sub surface moisture evaluations and recommendations for necessary repairs of defects and irregularities.
- D. Manufacturer's Representative: Provide a minimum of three site visits including one at start of work, one during progress and one at completion.

1.05 ENVIRONMENTAL REQUIREMENTS

- A. Do not apply roofing membrane during inclement weather.
- B. Do not apply roofing membrane to damp or frozen deck surfaces.
- C. Do not expose materials vulnerable to water or sun damage in quantities greater than can be weatherproofed during the same day.
- D. At lower air temperatures, to assure sound adhesion, care must be exercised to provide asphalt, at the point of application, at the asphalt's equiviscous temperature (EVT) plus 20 degrees Fahrenheit or at 400 degrees Fahrenheit, which ever is higher.

1.06 GUARANTEE

- A. Provide a twenty year total system guarantee covering the repair of leaks which result from either material or workmanship, including insulation, and attributable to ordinary wear and tear.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site in factory sealed cartons and crating bearing the manufacturer's labels.
- B. Store materials in weather protected environment, clear of ground and moisture, in accordance with manufacturer's instructions. Maintain membranes above 50 degrees Fahrenheit prior to their installation.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. The Garland Company
 - 2. W.P. Hickman Systems, Inc.
 - 3. Tremco Roofing

2.02 SYSTEM DESCRIPTION

- A. Four ply, hot asphalt applied modified bitumen membrane system with mineral granule surface cap sheet as the fourth ply.

2.03 SHEET MATERIALS

- A. Base Sheets: Glass Fiber 6 Ply Sheet: ASTM D2178, Type VI, UL Type G1 BUR.
- B. Membrane: Premium, fire-retarding, modified bitumen membrane and surfaced with light colored mineral granules. ASTM D6162 Type III cap sheet shall have the following properties:
 - 1. Minimum Thickness: 160 mils
 - 2. Tensile Strength (ASTM D-5147) 450 lbs.
 - 2. Tear Strength (ASTM D-5147) 900 lbs.

2.04 BITUMINOUS MATERIALS

- A. Asphalt Bitumen: ASTM D312, Type IV.
- B. Asphalt Primer: ASTM D41, GAF Asphalt/Concrete Primer.
- C. Asbestos-Free Cement: ASTM D 4586 Type II

2.05 INSULATION

- A. Provide insulation approved by the manufacturer and in accordance with the requirements of Section 07210, Building Insulation.
- B. Provide manufacturer's recommended high density fiberboard, 1/2 inches thick, above insulation where required by manufacturer to meet design requirements.

2.06 FLEXIBLE FLASHING

- A. Manufacturer's recommended modified bitumen flashing.

2.07 ACCESSORIES

- A. Roofing Nails: Galvanized or non-ferrous type and size as required to suit application.
- B. Pressure Relieving Vents: Plastic or Metal one-way valves. Provide vents in accordance with manufacturer's recommendations.
- C. Mechanical Fasteners for Insulation: Manufacturer's recommended fasteners and as required to meet FM I-90 requirements.
- D. Traffic Surfacing: Manufacturer's standard cap sheet of a color contrasting. Provide traffic surfacing from point of access to roof installed equipment, and each side of roof installed equipment

PART 3 -- EXECUTION

3.01 EXAMINATION

- A. Verify deck surface is dry, sound, clean and smooth, free of depressions, waves, or projections, properly sloped to gutter.
- B. Beginning of installation means acceptance of the surface of the substrates.

3.02 PROTECTION

- A. Protect building surfaces against damage from roofing work.
- B. Where work must continue over finished roof membrane, protect surfaces.

3.03 INSULATION APPLICATION

- A. For structural concrete decks, prime deck surface with Asphalt/Concrete Primer then embed in a 25 pound per square (plus or minus 20%) mopping of ASTM Type III or IV asphalt, two layers of insulation in accordance with manufacturer's instructions. Lay second layer of insulation with joints staggered from first layer.
- B. Lay insulation boards with tightly butted, staggered joints. Cut insulation to fit neatly to perimeter blocking and around protrusions through roof.
- C. Install no more insulation than can be properly covered by the end of the each day with roofing membrane.

3.04 MEMBRANE APPLICATION

- A. Install glass fiber ply sheets and modified bitumen sheets and flashing in accordance with manufacturer's instructions.
- B. Prime all masonry and metal surfaces with GAF Asphalt/ Concrete Primer and allow to dry thoroughly.

- C. Asphalt should be heated so that felts are installed with the asphalt within its equiviscous temperature range. Mop applied sheets must be installed with ASTM D 312, Type III or IV asphalt at a minimum temperature of 400 degrees Fahrenheit, at the point of application, with a target temperature of 425 degrees Fahrenheit, or 20 degrees Fahrenheit above the EVT, whichever is higher. The maximum allowable asphalt temperature, in the kettle, is 500 degrees Fahrenheit. Heat the asphalt in accordance with the manufacturer's instructions.
- D. Install glass fiber ply sheets using Type IV asphalt at a rate of 25 pounds per square (plus or minus 20%).
- E. Install membrane by solidly mopping in 25 pounds per square (plus or minus 20%) of asphalt to base.
- F. Apply glass fiber ply sheets and membrane smoothly without wrinkles, fishmouths or tears. Provide membrane side laps of 4 inches and 6 inch end laps. Side and end laps should have 1/4 inch minimum flow out of bitumen.
- G. Extend glass fiber ply sheets and membranes 2 inches past the top of the cants onto vertical surfaces.
- H. When inclement weather is expected, install a water cut-off at the end of the day's operation. Mop three plies of base sheets and one ply of membrane. Install cut-off at all exposed edges of roofing and at roof penetrations. Remove water cut-off upon resumption of work.

3.05 TRAFFIC SURFACING

- A. Using maximum 10' lengths of the cap sheet membrane solidly mop one ply of smooth membrane and one surfaced membrane to the surface of the applied roof. Allow 6"-12" openings between adjacent sheets for drainage.

3.06 FLASHING

- A. Install flashing according to Manufacturer's specifications.
- B. Install one pressure relief vent per 1,000 square feet, or part thereof, of roof surface.
- C. Seal flashing and flanges on all items setting on or protruding through the membrane. Seal flanges between two plies of membrane.

3.07 FIELD QUALITY CONTROL

- A. Inspection and testing will be performed by a Professional Engineering firm or manufacturer's representative approved by the Engineer.
- B. Correct defects and irregularities reported.

3.08 CLEANING

- A. Remove bituminous markings from finished surfaces. In areas where finished surfaces are soiled by asphalt or any other source of soiling caused by work of this section, consult manufacturer of surfaces for cleaning advice and conform to those instructions.

- END OF SECTION -

SECTION 07535

THERMOPLASTIC POLYOLEFIN (TPO) ROOFING, FULLY ADHERED

PART 1 – GENERAL

1.01 SCOPE

- A. This section covers the furnishing and installing of a fully adhered, TPO single-ply membrane roof system complete with adhesives, fasteners, flashings, insulation, and accessories.

1.02 GENERAL

- A. The roof deck of the new Electrical Building shall be covered with insulated, fully adhered single-ply membrane roofing system as indicated on the Drawings. The finished roof shall be watertight under all conditions of weather and service except physical damage due to unforeseen causes.
- B. The roof system shall meet UL rating Class A and shall be designed to withstand 120 mph peak wind gusts for a minimum three seconds without damage.
- C. Unless indicated otherwise, a complete total system guarantee covering all elements of the roofing system shall be furnished with this work. A warranty or guarantee which covers only the membrane will not be acceptable.

1.03 SUBMITTALS

- A. Complete specifications and data covering the roofing systems and materials furnished under this section shall be submitted in accordance with the Drawings and Submittals section.
- B. Drawings shall be submitted showing outline of roof area and roof size, locations and types of roof penetrations, perimeter and penetration details, splice details, special details as needed, and installation instructions.
- C. Drawings shall be submitted showing the insulation manufacturer's recommended layout for each area of insulation boards and crickets.
- D. Samples of the roofing membrane, insulation, and fasteners shall be submitted. Test data for pullout resistance for fastening systems shall be provided.
- E. Data shall be submitted showing compliance with UL requirements for the Class rating and the Factory Mutual wind uplift classification as indicated.
- F. Evidence shall be submitted which shows the roofing system installer to be an authorized applicator of the system furnished.

1.04 SUBCONTRACTOR'S QUALIFICATIONS

- A. Subcontractor shall be an installer who has met the highest level of installers for that manufacturer's roofing system. Subcontractor shall submit a qualification letter from the roofing manufacturer stating that the roofing contractor is an applicator and is able to offer the 30 year Total System NDL Guarantee required for this specific project. This qualification letter must accompany bid to the General Contractor.
- B. Unless indicated otherwise on the Drawings, work under this section shall be done by a qualified roofing subcontractor who has been in business for at least 5 years. The work shall be inspected by a representative of the membrane manufacturer to verify that materials and methods of application are in accordance with the recommendations of the manufacturer and with these specifications.
- C. Subcontractor shall coordinate and attend a pre-construction roof meeting with the General Contractor and the roofing manufacturer's technical representative prior to roof installation. Subcontractor shall submit a NOA (Notice of Award) and project information to roofing manufacturer prior to project start.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Shipping, handling and storage shall be in accordance with the Materials and Equipment section.
- B. Materials shall be delivered in original, unopened containers labeled with the manufacturer's name, brand name, installation instructions, and identification of various items. All materials for the roofing system shall be stored and handled in accordance with the recommendations of the manufacturer.

1.06 GUARANTEE

- A. Unless otherwise indicated, the manufacturer of the roofing membrane shall furnish to Owner, through the roofing subcontractor, a non- prorated, no dollar limit (30 year No Dollar Limit Guarantee), total roof system guarantee covering the workmanship and application of the roofing system including membranes, insulation, fasteners, and flashings for a period of 30 years from the date of acceptance.
- B. The guarantee shall provide for the repair of the total roofing system including repairs to membrane, flashings, insulation, barrier and cover boards, fasteners, adhesives and sealants resulting from all leaks in the membrane and base flashings that may occur due to defective materials, improper workmanship, and normal weather conditions. Unless otherwise indicated, the warranty shall include wind uplift protection to 120 mph peak gusts. The guarantee shall provide limited coverage for hail damage.
- C. In addition, the manufacturer shall also provide a separate material warranty covering the membrane for not less than 30 years against premature deterioration because of weather.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Unless noted otherwise, all materials used in construction of the roof system shall be furnished by the same manufacturer. Materials shall be manufactured by firms of national reputation.
- B. In order to indicate type, quality, and features required, this specification is based on GAF Everguard Extreme TPO fully adhered system. Equivalent roofing systems manufactured by other manufacturers may also be acceptable provided the requirements of these specifications are met.
- C. Materials shall conform to the following:

Roofing and Flashing Membrane, White	GAF Everguard 80 mil fleece back Extreme TPO
TPO Adhesive	Two part low rise polyurethane foam adhesive. VOC free and contains no solvents
Fasteners	Membrane manufacturer's standard. As recommended by roofing membrane manufacturer.
Water Cutoff Mastic	Membrane manufacturer's standard.
Night Sealant	Membrane manufacturer's standard.
Seam Fastening	Membrane manufacturer's standard.
Molded Pipe Flashing	Membrane manufacturer's standard.
Pourable Sealer	Membrane manufacturer's standard.
Cover Board	1/2" high density polyisocyanurate board (HD ISO Board). A COVER BOARD IS REQUIRED.
Insulation Polyisocyanurate	Polyisocyanurate foam with both sides faced with glass fiber felts; ASTM C1289, Type II; Apache "Pyrox", GAF "Isotherm", Schuller/NRG "E-NRGY-Y 2" or as recommended by the membrane manufacturer.

R-30 minimum average insulation value over entire roof. (Final insulation thickness to be determined by manufacturer as necessary to obtain required average R-value).

Mechanical Fasteners
Concrete Deck Applications

Corrosion resistant type as recommended by roofing membrane manufacturer, Factory Mutual approved for roof insulation used, and for fire and wind resistance requirements specified.

- D. Unless otherwise specified, metal edge flashing, cap flashings and similar metal components are covered in the Sheet Metal section, but shall be covered in the "30 Year Total System NDL Guarantee".

PART 3 – EXECUTION

3.01 INSPECTION

- A. The roofing membrane manufacturer's representative and the roofing subcontractor shall conduct all required inspections and shall submit to the roofing manufacturer all required drawings, details, and completed questionnaires for obtaining the specified warranty.
- B. A job start observation will be required with roofing manufacturer's technical representative present at project start. The representative shall witness actual roofing installation and shall submit a letter to the General Contractor and the Design Professional stating that the observed installation met the recommendations of the roofing manufacturer.

3.02 PREPARATION OF ROOF SURFACES

- A. Roof surfaces shall be cleaned and inspected before any roofing materials are applied. All drainage fixtures shall be set at the proper elevation to permit free flow of water.
- B. The roof surfaces to be covered shall be smooth, hard, dry, and free from high spots, depressions, and frost or effects of frost. Roof surfaces shall be swept clean and free from dust, loosened cement scale, and debris. Roof surfaces shall be examined for openings, holes, or crevices which might allow adhesives or sealants to drip or flow through the deck or between the deck and vertical projections. Such openings shall be filled or covered before any roofing materials are applied.

3.03 APPLICATION OF ROOFING

- A. System

1. The materials for the roofing systems shall be as specified herein. The roofing system assemblies shall conform to the following systems as indicated on the Drawings.

Cast-In Place or Precast Concrete Deck (without vapor retarder) Flat Structural Deck/Tapered Insulation:

Adhesive primer – manufacturer's standard as required.

Adhesive – Type III asphalt Polyisocyanurate Insulation, tapered. 1 layer of cover board ½" HD ISO. Crickets, where required.

Roof Membrane in LRF adhesive.

B. Nailers

1. Nailers shall be as specified in the Rough Carpentry section. Nailers shall be secured as specified by the roofing membrane manufacturer and as specified by FM Bulletin 1-49. Wood nailers shall be installed at the locations specified herein, as indicated on the Drawings, and as recommended by the membrane manufacturer.

C. Insulation

1. Insulation shall be dry when installed. No more insulation shall be installed than can be covered with roofing membrane before the end of the day's work or before the onset of inclement weather.
2. Unless otherwise specified, insulation shall be laid over the substrate, with joints no wider than 1/4 inch. Joints wider than 1/4 inch shall be filled with the same insulation.
3. Insulation boards shall be laid with joints staggered between parallel courses and, if required, between layers. Abutting edges of boards shall be laid in moderate contact, not forced into place. At vertical surfaces, insulation shall be cut neatly to provide a clearance of not more than 1/4 inch.
4. Insulation boards for tapered systems shall be positioned in accordance with the manufacturer's layout to produce roof slopes and drainage patterns as indicated on the Drawings. The installed thickness of insulation shall be as indicated on the Drawings.
5. Crickets to provide positive roof drainage as indicated on the Drawings, shall be installed as indicated on the Drawings and per the manufacturer's instructions.
6. All insulation over metal roof decks shall be in accordance with the manufacturer's recommendations.

7. When high wind uplift is required, anchorage of insulation boards and cover boards shall be provided complete with all necessary anchors, special anchors, and appurtenances to meet the performance and warranty requirements.

D. Cover Board.

1. Cover boards shall be installed over all insulation. Cover boards shall be attached as recommended by the membrane manufacturer for the wind design specified.

E. Membrane

1. The roofing membrane shall be positioned over the installed insulation without stretching. Membrane shall be allowed to relax for approximately 1/2 hour prior to bonding.
2. Sheets of membrane shall be positioned to provide a 3 inch minimum edge lap with adjacent sheets. Adhesive shall be applied to the membrane and the underlying substrate to securely bond the membrane to the board according to the manufacturer's recommendations. Membrane shall be rolled to eliminate wrinkles, pockets, or voids. Joints in the membrane shall be cleaned and permanently joined at the overlap as recommended by the membrane manufacturer. Special care shall be taken to minimize staining and damage to the exposed membrane surfaces by the sealants.
3. At the end of each day or whenever application of roofing is interrupted, temporary water cutoffs shall be installed at loose edges as recommended by the membrane manufacturer. When work is resumed, the sheet shall be pulled free and trimmed to remove membrane where sealant was previously applied.

F. Securing Perimeter Membrane

1. Sheets of membrane shall be secured at the perimeter of each roof level, roof section, curb, and parapet wall, where required, using fastening strips or reinforced universal securement strips mechanically fastened through the membrane and insulation into the wood blocking or structural substrate as recommended by the membrane manufacturer.

G. Flashing

1. Perimeter and roof edge flashings, where required, of TPO membranes shall be provided and installed as recommended by the membrane manufacturer. All pipe, conduits, or other roof penetrations shall be flashed with molded pipe flashings and the manufacturer's recommended water cutoff mastic.

H. Cleanup

1. Following installation of roofing materials, the roof surface shall be cleaned of all construction materials, traffic grime, accumulated dirt, excess sealants, and other

debris. The membrane surface shall be cleaned as recommended by the membrane manufacturer.

- END OF SECTION -

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SECTION 07920

SEALANTS AND CAULKING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall provide sealant and caulking work required for a complete installation as is indicated on the Drawings and specified herein. The required applications of sealants and caulking include, but are not necessarily limited to, the following general locations:
 - 1. Masonry joints, exterior and interior.
 - 2. Joints at penetrations of walls, decks by piping, doors, windows, louvers and other services and equipment.
 - 3. Joints between items of equipment and other construction.
 - 4. Exterior Insulation Finish joints.
- B. Joints in Concrete are specified in Section 03290 entitled "Joints in Concrete".

1.02 MANUFACTURERS

- A. The following list of companies manufacture products that are acceptable for this section, subject to conformance with the specified requirements: Sika, Tremco, Thiokol, Dymoric or equal.

1.03 SUBMITTALS

- A. Submit shop drawings and color samples of sealant for review in accordance with Section 01300 entitled "Submittals".
- B. Submit to the Owner, in accordance with Section 01300 entitled "Submittals", a two year guarantee on sealant type caulking work against joint failure. Joint failure is defined as leaks of air or water; evidence of loss of cohesion; fading of sealant material; migration of sealant; evidence of loss of adhesion between sealant and joint edge.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Primer
 - 1. Where required by sealant Manufacturer, the non-staining primer shall be a compound designed to insure the adhesion of sealant. Material shall be provided by the sealant Manufacturer and shall be selected for compatibility with substrate.

B. Sealant

1. Sealant for vertical joints shall be two component polyurethane sealant meeting FSTTS 00227E. Colors shall be selected by the Engineer.
2. Sealant for horizontal joints (non-contaminated) shall be a single component, pour grade, polyurethane sealant meeting FS TT S 230A, Type 1. Materials shall attain Shore A Hardness of 40 45.
3. Sealant for horizontal joints (contaminated) shall be a single component, pour grade, coal tar edition, with amendments. Material shall attain Shore A Hardness of 25 30.

C. Caulking Compound

1. Caulking Compound for setting thresholds and for other interior caulking shall be oleo resinous, gun grade, non-staining plastic compound conforming to FS TT C 598 b. Material shall have shrinkage factor not exceeding 15%.

D. Joint Backing

1. Joint backing shall be closed cell foam. Material shall be nonreactive with caulking materials and non-oily. Minimum density shall be 2.00 pcf. Use no asphalt or bitumen impregnated fiber with sealants.

E. Joint Cleaner

1. Joint cleaner shall be as recommended by sealant or caulking compound Manufacturer.

F. Joint Primer

1. Joint primer shall be as recommended by sealant Manufacturer.

G. Bond Breaker

1. Bond breaker tape shall be either polyethylene or plastic as recommended by the sealant Manufacturer.

H. Color

1. Where Manufacturer's standard colors do not closely match materials being sealed, provide a custom color.

PART 3 – EXECUTION

3.01 GENERAL

- A. Comply with sealant Manufacturer's printed instructions except where more stringent requirements are shown or specified and except where Manufacturer's technical representative directs otherwise.

3.02 SHIPPING, HANDLING AND STORAGE

- A. Store and handle materials so as to prevent the inclusion of foreign matter or the damage of materials by water or breakage. Procure and store in original containers until ready for use. Material showing evidence of damage will be rejected.
- B. Store and handle materials so as to prevent the inclusion of foreign matter or the damage of materials by water or breakage. Procure and store in original containers until ready for use. Material showing evidence of damage shall be rejected.

3.03 INSTALLATION

- A. Employ only proven installation techniques, which will ensure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of the joint bond surface equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.
- B. Install sealants to depths as specified, or if not, as recommended by the sealant Manufacturer and as follows:
 - 1. Moving Joints
 - a. For normal moving joints sealed with elastomeric sealants but not subject to traffic, fill joints to a depth equal to 50% of joint width, but not more than 1/2-inch deep or less than 1/4-inch deep.
 - 2. Sealed Joints
 - a. For joints sealed with nonelastomeric sealants and caulking compounds, fill joints to a depth in the range of 75% to 125% of joint width.
 - 3. Thresholds
 - a. Set thresholds in full bed of caulking compound; remove excess materials.

3.04 PROTECTION OF ADJOINING SURFACES

- A. Prime or seal the joint surfaces as shown or recommended by the sealant Manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.

3.05 SEALANT BACKER ROD

- A. Install sealant backer rod for liquid elastomeric sealants, except where shown to be omitted or recommended to be omitted by sealant Manufacturer for the application shown.

3.06 BOND BREAKER

- A. Install bond breaker tape wherever shown and wherever required by Manufacturer's recommendations to ensure that elastomeric sealants will perform properly.

3.07 SPILLAGE

- A. Sealants or compounds shall not overflow or spill onto adjoining surfaces, or to migrate into the voids of adjoining surfaces. Masking tape or other precautionary devices shall be used to prevent staining of adjoining surfaces.

3.08 CURING

- A. Sealants and caulking compounds shall be cured in compliance with Manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength, and surface durability.

3.09 CLEANING

- A. Excess and spillage of compounds shall be promptly removed as the work progresses. Adjoining surfaces shall be cleaned by whatever means may be necessary to eliminate evidence of spillage. Do not damage the adjoining surfaces or finishes.

- END OF SECTION -

SECTION 08225

FIBERGLASS DOORS AND FRAMES

PART 1 – GENERAL

1.01 SCOPE

- A. This section covers fiberglass reinforced plastic doors and frames. Unless otherwise indicated or specified, all FRP doors shall be flush type. All doors and frames shall be provided by a single manufacturer.

Finish Hardware is covered in the Finish Hardware section. Glazing is covered in the Glass and Glazing section.

1.02 GENERAL

- A. Doors, frames, and appurtenances shall be furnished and installed as specified herein and in accordance with the details and arrangements indicated on the Drawings.

Subject to the requirements specified herein, FRP doors shall be equivalent to Chem-Pruf "CP1" FRP doors.

1.03 SUBMITTALS

- A. Complete detail drawings of all items specified herein shall be submitted in accordance with the Drawings and Submittals section. Drawings shall show elevations of each door type; details of each frame type; location or identification of each item; typical and special details of construction; methods of assembling sections; location and installation requirements for hardware; size, shape, and thickness of materials; joints; connections; and finish.

Submitted equivalent FRP door manufacturers will not be acceptable if the door face sheet thickness cannot be verified as an equivalent to the minimum thickness in inches as specified herein.products

1.04 MATERIALS

Materials used in the manufacture and installation of FRP doors and frames shall be as follows:

Doors	Fiberglass reinforced plastic face sheets, 0.125 inch minimum thickness, polypropylene honeycomb core, manufacturer 25 year warranty.

Internal Reinforcing	Manufacturer's standard.

Frame	Solid, all-fiberglass frame with molded-in color conforming to SDI dimensions for profiles shown.
Face Sheet	Fine pebble textured, semi-gloss gel coat finish, minimum 15mil thickness, abuse-resistant engineered surface.
Anchoring Devices	Stainless Steel.

A. Shop Finish

1. The finished surfaces shall be smooth and free from irregularities. The color for the new FRP doors will be selected from the manufacturer's full line of standard and optional colors. A manufacturer provided color chart and sample shall be provided for color selection. Generically printed color charts will not be acceptable.

1.05 FRAMES

- A. Frames for doors shall be formed of fiberglass reinforced plastic shapes with molded-in color shall be a minimum 3/16 inch in thickness for the profile indicated on the Drawings, with approximately 2-inch face as indicated on the Drawings. The frame face shall be sized according to the actual size and width of the opening provided. Resins for frames shall match those used for doors.

B. Workmanship

1. The finished work shall be strong and rigid, neat in appearance, and free from defects. Molded members shall be fabricated straight and true, with corner joints well formed, and with fastenings concealed where practicable.

C. Joints

1. Joints for frames shall be mitered or butted and continuously sealed on the reverse side to produce rigid joints which are invisible on the face of the frame. Frame bottoms shall be held rigidly in position by spreader bars to maintain proper alignment during shipment and erection.

D. Hardware Provisions

1. Frames shall be prepared at the factory for the specified hardware. Frames shall be mortised, reinforced, drilled, and tapped for mortised hardware, and shall be reinforced for surface- applied hardware. Cover boxes shall be provided in back of all hardware cutouts.

Fiberglass reinforced plastic frames shall have concealed reinforcements for hardware according to manufacturer's standards.

E. Wall and Floor Anchors

1. Metal anchors shall be of the sizes and shapes required for the type of adjoining wall construction. Jamb anchors shall be located near the top and bottom of each frame and at intermediate points not to exceed 32 inch spacing.

1.06 DOORS

- A. Doors indicated on the Drawings as flush fiberglass reinforced plastic, including doors with glazed openings, shall be as specified herein. Doors shall be prepared to receive the hardware specified in the finish hardware section.

B. Workmanship

1. Doors shall be rigid, neat in appearance, and free from defects. Molded members for glazed doors shall be formed straight and true, with joints coped or mitered, well formed, and in true alignment. All joints on exposed surfaces shall be smooth so that they are invisible after finishing.

C. Sizing and Clearances

1. Doors shall be 1-3/4 inches thick, full flush type, of the sizes and design indicated. Clearances for doors shall be 1/8 inch at jambs and heads, 1/4 inch at meeting stiles of pairs of doors, and 3/4 inch at bottom unless otherwise indicated or specified.

D. Construction

1. Doors shall be constructed with at least 0.125 inch fiberglass reinforced plastic outer sheets. Side edges of doors shall be flush and closed watertight. All seams shall be continuously sealed. Doors shall be prepared at the factory for hardware and for glazing as indicated on the Drawings and as specified.

Outswinging exterior doors shall be finished flush at the top, with all seams and joints closed watertight as specified for side edges.

E. Hardware Provisions

1. Doors shall be mortised, reinforced, drilled, and tapped for mortised hardware. Reinforcing units shall be provided for locksets. Reinforcing plates shall be provided for mortised and surface-applied hardware according to manufacturer's standards.

The location of hardware items shall be in accordance with DHI "Recommended Locations for Builders' Hardware for Standard Steel Doors and Frames".

PART 2 – EXECUTION

2.01 INSTALLATION

- A. Frames shall be set in position, plumbed, aligned, and braced securely until permanent anchors are set.

Frames set in existing or new walls shall be anchored to walls with non-corroding expansion anchors or as otherwise required by frame manufacturer. Frame placement within the wall construction shall be as indicated on the Drawings.

- END OF SECTION -

SECTION 08710
FINISH HARDWARE

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. The work in this section shall include furnishing of all items of finish hardware as hereinafter specified or obviously necessary to complete the building, except those items that are specifically excluded from this section of the specification.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. FRP Doors and Frames

1.03 DESCRIPTION OF WORK

- A. Furnish labor and material to complete hardware work indicated, as specified herein, or as may be required by actual conditions at building.
- B. Include all necessary screws, bolts, expansion shields, other devices, if necessary, as required for proper hardware application. The hardware supplier shall assume all responsibility for correct quantities.
- C. Hardware shall meet the requirements of Federal, State and Local codes having jurisdiction over this project, notwithstanding any real or apparent conflict therewith in these specifications.
- D. Fire-rated openings
 - 1. Provide hardware for fire-rated openings in compliance with A.I.A. (NBFU) Pamphlet No. 80, NFPA Standards NO. 101, UBC 702 (1997) and UL10C. This requirement takes precedence over other requirements for such hardware. Provide only hardware that has been tested and listed by UL for the types and sizes of doors required, and complies with the requirements of the door and door frame labels.
 - 2. Panic exit devices are required on fire-rated doors, provide supplementary marking on door UL label indicating Fire Door to be equipped with fire exit hardware and provide UL label on exit device indicating "Fire Exit Hardware".
- E. Hurricane Openings
 - 1. Provide hardware for hurricane openings in compliance with local jurisdiction. This requirement takes precedence over other requirements for such hardware. Provide only hardware that has been tested and listed by local authority for the types and

sizes of doors required, and complies with the requirements of the door and door frame.

F. Fasteners:

1. Hardware as furnished shall conform to published templates generally prepared for machine screw installation.
2. Furnish each item complete with all screws required for installation. Typically, all exposed screws installation.
3. Insofar as practical, furnished concealed type fasteners for hardware units that have exposed screws shall be furnished with Phillips flat head screws, finished to match adjacent hardware.
4. Door closers and exit devices to be installed with closed head through bolts (sex bolts).

1.04 QUALITY ASSURANCE

- A. The supplier to be a directly franchised distributor of the products to be furnished and have in their employ an AHC (Architectural Hardware Consultant). This person is to be available for consultation to the architect, owner and the general contractor at reasonable times during the course of work.
- B. The finish hardware supplier shall prepare and submit to the architect six (6) copies of a complete schedule identifying each door and each set number, following the numbering system and not creating any separate system himself. He shall submit the schedule for review, make corrections as directed and resubmit the corrected schedule for final approval. Approval of schedule will not relieve Contractor of the responsibility for furnishing all necessary hardware, including the responsibility for furnishing correct quantities.
- C. No manufacturing orders shall be placed until detailed schedule has been submitted to the architect and written approval received.
- D. After hardware schedule has been approved, furnish templates required by manufacturing contractors for making proper provisions in their work for accurate fitting, finishing hardware setting. Furnish templates in ample time to facilitate progress of work.
- E. Hardware supplier shall have an office and warehouse facilities to accommodate the materials used on this project. The supplier must be an authorized distributor of the products specified.
- F. The hardware manufactures are to supply both a pre-installation class as well as a post-installation walk-thru. This is to insure proper installation and provide for any adjustments or replacements of hardware as required.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Wrap, protect finishing hardware items for shipment. Deliver to manufacturing contractors hardware items required by them for their application; deliver balance of hardware to job; store in designated location. Each item shall be clearly marked with its intended location.

1.06 WARRANTY

- A. The material furnished shall be warranted for one year after installation or longer as the individual manufacturer's warranty permits.
- B. The manufacturer against failure due to defective materials and workmanship shall warrant overhead door closers in writing for a period of ten (10) years. Commencing on the Date of Final Completion and Acceptance, and in the event of failure, the manufacture is to promptly repair or replace the defective with no additional cost to the Owner.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. To the greatest extent possible, obtain each kind of hardware from only one manufacturer.
- B. All numbers and symbols used herein have been taken from the current catalogues of the following manufacturers.

PRODUCT	ACCEPTABLE MANUFACTURER	ACCEPTABLE SUBSTITUTE
1) Hinges	Ives	Hager, Stanley , Bommer
2) Locks & Latches	Schlage	None (Owner preferred)
3) Cylinders, Keys, Keying	Schlage Everest 29 w/ Primus XP	None (Owner preferred)
4) Exit Devices	Von Duprin	None (Owner preferred)
5) Door Closers	LCN	None (Owner preferred)
6) OH Stops/Holders	Glynn Johnson	Rixson, Hager
7) Magnetic Hold Opens	LCN	Dor-O-Matic
8) Wall Stops/Floor Stops, Flushbolts	Ives	Rockwood, G J, Hager
9) Kick Plates	Ives	Rockwood, Hager
10) Thresholds/Weather-strip	National Guard	Pemko, Zero, Hager
11) Silencers	Ives	Rockwood, GJ, Hager
12) Key Cabinet	Lund	Key Control

- C. If material manufactured by other than that specified or listed herewith as an equal, is to be bid upon, permission must be requested from the architect seven (7) days prior to bidding. If substitution is allowed, it will be so noted by addendum.

2.02 FINISH OF HARDWARE

- A. Exterior Hinges to be Stainless Steel (32D), Interior Hinges to be Satin Chrome (26D). Door Closers to be Aluminum. Locks to be Satin Chrome (26D), Exit Devices to be Satin Chrome (26D). Overhead Holders to be Satin Chrome (26D), Flat Goods to be Satin Chrome (26D) or Stainless Steel (32D) and the Thresholds to be Mill Finish Aluminum.

2.03 HINGES AND PIVOTS

- A. Exterior butts shall be Stainless Steel. Butts on all out swinging doors shall be furnished with non-removable pins (NRP).
- B. Interior butts shall be as listed.
- C. Doors 5' or less in height shall have two (2) butts. Furnish one (1) additional butt for each 2'6" in height or fraction thereof. Dutch door shall have two (2) butts per leaf.

2.04 KEYING

- A. All locks and cylinders shall be 11 Pin Schlage Primus XP Interchangeable Core key system, the City of Orlando Lock and Security personnel shall issue all bittings.
- B. Provide Two (2) each change keys per lock and Six (6) each grand master and master keys. All keys to be Patent Restricted Schlage Primus XP Level III.
- C. Hardware supplier to provide temporary cylinders or cores during the construction phase.
- D. 90 days prior to substantial completion the contractor must deliver all Schlage Primus XP cores to the city's Security and Lock personnel.
- E. The City's Locksmith is to change out the temporary cylinders for the permanent cylinders. The temporary cylinders will be returned to contractor upon completion.

2.05 LOCKSETS

- A. Locksets for interior doors shall be Heavy-Duty Cylindrical type, unless specified otherwise, in "ND" series, Rhodes design as manufactured by Schlage.
- B. Locksets for exterior doors shall be panic device as specified or full case mortice lock as in Schlage L9000 series.

1. Acceptable Substitutions

- a. None (No Substitutions)

2.06 EXIT DEVICES

- A. Exit devices shall be Von Duprin 98 Series in types and functions specified. All devices must be listed under "Panic Hardware" in accident equipment list of Underwriters Laboratories. All labeled doors with "Fire Exit Hardware" must have labels attached and be in strict accordance with Underwriters Laboratories.
- B. All exit devices shall be tested to ANSI/BHMA A156.3 test requirements by a BHMA certified testing laboratory. A written certification showing successful completion of a minimum of 1,000,000 cycles must be provided.
- C. All surface strikes shall be roller type and come complete with a plate underneath to prevent movement. And shall be provided with a dead-latching feature to prevent latchbolt tampering.
 - 1. Acceptable substitutions:
 - a. None (No Substitution)

2.07 DOOR CLOSERS

- A. All closers shall be LCN 4011/4111 series having non-ferrous covers, forged steel arms separate valves for adjusting backcheck, closing and latching cycles and adjustable spring to provide up to 50% increase in spring power. Closers shall be furnished with parallel arm mounted on all doors opening into corridors or other public spaces and shall be mounted to permit 180 degrees door swing wherever wall conditions permit. Furnish with non-hold open arms unless otherwise indicated.
- B. Door closer cylinders shall be of high strength cast iron construction to provide low wear operating capabilities of internal parts throughout the life of the installation. All door closers shall be tested to ANSI/BHMA A156.4 test requirements by a BHMA certified testing laboratory. A written certification showing successful completion of a minimum of 10,000,000 cycles must be provided.
- C. Door closers shall utilize temperature stable fluid capable of withstanding temperature ranges of 120 degrees Fahrenheit to -30 degrees Fahrenheit, without requiring seasonal adjustment of closer speed to properly close the door. Closers for fire-rated doors shall be provided with temperature stabilizing fluid that complies with the standards UBC 7-2 (1997) and UL 10C.
- D. Door closers shall incorporate tamper resistant non-critical screw valves of V-slot design to reduce possible clogging from particles within the closer. Closers shall have separate and independent screw valve adjustments for latch speed, general speed, and hydraulic backcheck. Backcheck shall be properly located so as to effectively slow the swing of the door at a minimum of 10 degrees in advance of the dead stop location to protect the door frame and hardware from damage. Pressure relief valves (PRV) are not acceptable.

1. Acceptable substitutions:
2. None (No Substitution)

2.08 TRIM AND PLATES

- A. Kick plates, mop plates, and armor plates, shall be .050 gauge with 32D finish. Kick plates to be 10" high, mop plates to be 4" high. All plates shall be two (2) inches less full width of door.
- B. Push plates, pull plates, door pulls, and miscellaneous door trim shall be shown in the hardware schedule.

2.09 DOOR STOPS

- A. Doorstops shall be furnished for all doors to prevent damage to doors or hardware from striking adjacent walls or fixtures. Wall bumpers equal to IVES WS407 Series are preferred, but where not practical furnish floor stops equal to IVES FS436 or FS438 series. Where conditions prohibit the use of either wall or floor type stops, furnish surface mounted overhead stops equal to Glynn Johnson, 450 Series.

2.10 THRESHOLDS AND WEATHERSTRIP

- A. Thresholds and weather-strip shall be as listed in the hardware schedule.

2.11 DOOR SILENCERS

- A. Furnish rubber door silencers equal to IVES SR64 for all new interior hollow metal frames, (2) per pair and (3) per single door frame

PART 3 – EXECUTION

3.01 INSTALLATION:

- A. All hardware shall be applied and installed in accordance with the Finish Hardware schedule. Care shall be exercised not to mar or damage adjacent work.
- B. Contractor to provide a secure lock-up for hardware delivered to the project but not yet installed. Control the handling and installation of hardware items that are not immediately replaceable, so that the completion of the work will not be delayed by hardware losses both before and after installation.
- C. No hardware is to be installed until the hardware manufactures have provided a pre-installation class and post-installation inspection. This is to insure proper installation of the specified products.

3.02 ADJUSTING AND CLEANING:

- A. Contractor shall adjust all hardware in strict compliance with manufacturer's instructions. Prior to turning project to owner, contractor shall clean and make any final adjustments to the finish hardware.

3.03 PROTECTION:

- A. Contractor shall protect the hardware, as it is stored on construction site in a covered and dry place.
- B. Contractor shall protect exposed hardware installed on doors during the construction phase.

3.04 KEY CABINET:

- A. Set up and index one (1) Key Cabinet that allows room for expansion for 150% of the number of keys for the project.

3.05 HARDWARE SCHEDULE:

- A. The following schedule is furnished for whatever assistance it may afford the contractor; do not consider it as entirely inclusive. Should any particular door or item be omitted in any scheduled hardware group, provide door or item with hardware same as required for similar purposes. Quantities listed are for each pair of doors or for each single door.

Set #1 (*Exterior, 3'-0" x 7'-2", Locked, Panic*)
Doors 101A, 001A, & 001B

Item	# Req'd	Detail	Finish
Hinges	3	4-1/2x4-1/2 with non-removable pin	32D
Exit Device	1	Rim exit device	630
Closer	1	With hold-open function	EN
Threshold	1	252X2-A-FG (Pemko)	
Gasketing	1 set	2891AS head & 290AS jamb (Pemko)	
Raindrip	1	2-1/2" projection	
Bottom Sweep	1	Surface-mount neoprene sweep	

Set #2 (*Exterior, 3'-8" x 7'-10", Locked, Panic*)
Doors 101B

Item	# Req'd	Detail	Finish
Hinges	4	4-1/2x4-1/2 with non-removable pin	32D
Exit Device	1	Rim exit device	630

Closer	1	With hold-open function	EN
Threshold	1	252X2-A-FG (Pemko)	
Gasketing	1 set	2891AS head & 290AS jamb (Pemko)	
Raindrip	1	2-1/2" projection	
Bottom Sweep	1	Surface-mount neoprene sweep	

- END OF SECTION -

SECTION 09900

PAINTING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment, and appliances required for complete execution of Work shown on Drawings and Specified herein.
- B. Section Includes:
- C. Paint Materials
- D. Shop Painting
- E. Field Painting
 - 1. Surface Preparation
 - 2. Piping and Equipment Identification
 - 3. Schedule of Colors
 - 4. Work in Confined Spaces
 - 5. OSHA Safety Colors

1.02 RELATED SECTIONS

- A. Section 15030 – Piping and Equipment Identification Systems

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:
- B. SSPC – The Society for Protective Coatings Standards
 - 1. SSPC-Vis 1 – Pictorial Surface Preparation Standards for Painting Steel Structures
 - 2. SSPC-SP2 – Hand Tool Cleaning
 - 3. SSPC-SP3 – Power Tool Cleaning
 - 4. SSPC-SP5/NACE 1 – White Metal Blast Cleaning
 - 5. SSPC-SP6/NACE 3 – Commercial Blast Cleaning

- 6. SSPC-SP7/NACE 4 – Brush-off Blast Cleaning
- 7. SSPC-SP10/NACE 2 – Near-White Metal Blast
- 8. SSPC-SP11 – Power Tool Cleaning to Bare Metal
- 9. SSPC-SP13/NACE6 – Surface Preparation of Concrete
- C. ICRI – International Concrete Repair Institute
- D. NACE – National Association of Corrosion Engineers
- E. NAFPP – The National Association of Pipe Fabricators
- F. ASTM D1737 – Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus
- G. ASTM B117 – Method of Salt Spray (Fog) Testing
- H. ASTM D4060 – Test Method for Abrasion Resistance of Organic Coating by the Taber Abraser
- I. ASTM D3359 – Method for Measuring Adhesion by Tape Test

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01300 – Submittal Procedures, submit the following:
- B. Manufacturer's literature and Material Safety Data Sheets for each product.
- C. Painting schedule identifying surface preparation and paint systems proposed. Cross reference with Tables 1 and 2. Provide the name of the paint manufacturer, and name, address, and telephone number of manufacturer's representative who will inspect the work. Submit schedule for approval as soon as possible following the Award of Contract, so approved schedule may be used to identify colors and specify shop paint systems for fabricated items. Manufacturer shall substitute paint system with equal performance where required for VOC compliance.
- D. Contractor shall submit Q.C. Inspection plan describing all tests and inspections task to be performed. Include copy of daily log showing environmental conditions measurements and frequency. Copy of completed log shall be provided at completion of work.

1.05 SYSTEM DESCRIPTION

- A. Work shall include surface preparation, paint application, inspection of painted surfaces and corrective action required, protection of adjacent surfaces, cleanup and appurtenant work required for the proper painting of all surfaces to be painted. Surfaces to be painted are designated within the Painting Schedule and may include new and existing piping,

miscellaneous metals, equipment, buildings, exterior fiberglass, exposed electrical conduit and appurtenances.

- B. Perform Work in strict accordance with manufacturer's published recommendations and instructions, unless the Engineer stipulates that deviations will be for the benefit of the project.
- C. Paint surfaces which are customarily painted, whether indicated to be painted or not, with painting system applied to similar surfaces, areas and environments, and as approved by Engineer.
- D. Submerged ferrous metal, piping, and internal pump surfaces within potable water facilities or potable water distribution systems shall be painted with NSF 61/600 approved coatings.
- E. Piping and equipment shall receive color coding and identification. Equipment shall be the same color as the piping system.

1.06 QUALITY ASSURANCE

- A. Painting operations shall be accomplished by skilled craftsman and licensed by the state/commonwealth to perform painting work.
- B. Provide a letter indicating that the painting applicator has five years of experience, and 5 references which show previously successful application of the specified or comparable painting systems. Include the name, address, and the telephone number for the Owner of each installation for which the painting applicator provided services.
- C. Contractor shall coordinate Q.C Inspections.
- D. Notify Owner and Engineer at completion of surface preparation, priming application and final cure to allow inspection by Owner and Engineer or their Third-Party Inspector.

1.07 STORAGE AND DELIVERY

- A. Bring materials to the job site in the original sealed and labeled containers.
- B. Container label to include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Store paint materials at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

PART 2 – MATERIALS

2.01 GENERAL INFORMATION

- A. The term "paint" is defined as both paints and coatings including emulsions, enamels, stains, varnishes, sealers, and other coatings whether organic or inorganic and whether used as prime, intermediate, or finish coats.
- B. Purchase paint from an approved manufacturer. Manufacturer shall assign a representative to inspect application of their product both in the shop and field. The manufacturer's representative shall submit a report to the Engineer at the completion the Work identifying products used and verifying that surfaces were properly prepared, products were properly applied, and the paint systems were proper for the exposure and service.
- C. Provide primers and intermediate coats produced by same manufacturer as finish coat. Use only thinners approved by paint manufacturer, and only within manufacturer's recommended limits.
- D. Ensure compatibility of total paint system for each substrate. Test shop primed equipment delivered to the site for compatibility with final paint system. Provide an acceptable barrier coat or totally remove shop applied paint system when incompatible with system specified and repaint with specified paint system.
- E. Use painting materials suitable for the intended use and recommended by paint manufacturer for the intended use.
- F. Require that personnel perform work in strict accordance with the latest requirements of OSHA Safety and Health Standards for construction. Meet or exceed requirements of regulatory agencies having jurisdiction and the manufacturer's published instructions and recommendations. Maintain a copy of all Material Safety Data Sheets at the job site of each product being used prior to commencement of work. Provide and require that personnel use protective and safety equipment in or about the project site. Provide respiratory devices, eye and face protection, ventilation, ear protection, illumination and other safety devices required to provide a safe work environment.

2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
 - 1. Tnemec Company Inc.
 - 2. PPG
 - 3. CARBOLINE
 - 4. Sherwin-Williams

PART 3 – EXECUTION

3.01 SHOP PAINTING

- A. Shop prime fabricated steel and equipment with at least one shop coat of prime paint compatible with finish paint system specified. Prepare surface to be shop painted in strict accordance with paint manufacturer's recommendations and as specified. Finish coats may be shop applied, if approved by the Engineer. Package, store and protect shop painted items until they are incorporated into Work. Repair painted surfaces damaged during handling, transporting, storage, or installation to provide a painting system equal to the original painting received at the shop.
- B. Identify surface preparation and shop paints on Shop Drawings. Verify compatibility with field applied paints.
- C. Coordinate shop painting and field coating to ensure item is delivered and field coating occurs within recoat window of shop painted system requirements.

3.02 SURFACE PREPARATION

- A. General
 - 1. Surfaces to be painted shall be clean and dry, and free of dust, rust, scale, and foreign matter. No solvent cleaning, power or hand tool cleaning shall be permitted unless approved by the Engineer.
 - 2. Protect or remove, during painting operations, hardware, accessories, machined surfaces, nameplates, lighting fixtures, and similar items not intended to be painted prior to cleaning and painting. Reposition items removed upon completion of painting operations.
 - 3. Examine surfaces to be coated to determine that surfaces are suitable for specified surface preparation and painting. Report to Engineer surfaces found to be unsuitable in writing. Do not start surface preparation until unsuitable surfaces have been corrected. Starting surface preparation precludes subsequent claim that such surfaces were unsuitable for the specified surface preparation or painting.
 - 4. Surface preparation shall be in accordance with specifications and manufacturer's recommendations. Provide additional surface preparation, and fill coats where manufacturer recommends additional surface preparation, in addition to requirements of specification.
 - 5. Touch-up shop or field applied coatings damaged by surface preparation or any other activity, with the same shop or field applied coating; even to the extent of applying an entire coat when required to correct damage prior to application of the next coating. Touchup coats are in addition to the specified applied systems, and not considered a field coat.

6. Protect motors and other equipment during blasting operation to ensure blasting material is not blown into motors or other equipment. Inspect motors and other equipment after blasting operations and certify that no damage occurred, or where damage occurred, the proper remedial action was taken.
7. Field paint shop painted equipment in compliance with Color Coding and as approved by Engineer.

B. Metal Surface Preparation

1. Prepare all welds to a minimum NACE weld preparation level "C" per NACE Standard SP0178. Provide additional weld preparation where required by the coating manufacturer. Contractor shall provide NACE SP0178 weld mold visual aids on site for evaluation of all weld preparation.
2. Conform to current The Society for Protective Coatings Standards (SSPC) Specifications for metal surface preparation. Use SSPC-Vis-1 pictorial standards or NACE visual standards TM-01-70 or TM-01-75 to determine cleanliness of abrasive blast cleaned steel.
3. Perform blast cleaning operations for metal when following conditions exist:
 - a. Moisture is not present on the surface.
 - b. Relative humidity is below 80%.
 - c. Ambient and surface temperatures are 5°F or greater than the dew point temperature.
 - d. Painting or drying of paint is not being performed in the area.
 - e. Equipment is in good operating condition.
 - f. Proper ventilation, illumination, and other safety procedures and equipment are being provided and followed.
4. Abrasive blast ferrous metals to be shop primed, or component mechanical equipment in accordance with SSPC-SP5, White Metal Blast.
5. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP10, Near White Metal Blast, where metal is to be submerged, in a corrosive environment, or in severe service. Provide a 3.0 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
6. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP6 Commercial Blast, where metal is to be used in mild or moderate service, or non-corrosive environment or weathering exposure. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.

7. Clean nonferrous metals, copper, or galvanized metal surfaces in accordance to SSPC-SP1, Solvent Cleaning, or give one coat of metal passivator or metal conditioner compatible with the complete paint system. Galvanized metal shall be prepared in accordance with SSPC SP-16. Abrasive blast clean to increase mechanical adhesion in accordance with ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting when required by coating manufacturer. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
8. Abrasive blast clean internal and external ductile iron pipe surfaces prior to coating in accordance with NAPF 500-03-04, Surface Preparations Standard for Abrasive Blast Cleaning of Ductile Iron Pipe. Abrasive blast clean internal and external cast ductile iron and cast-iron fitting surfaces in accordance with NAPF-03-05.
9. Prime cleaned metals immediately after cleaning to prevent rusting.
10. Clean rusted metals down to bright metal by abrasive blasting and immediately field primed.

C. Concrete Surface Preparation

1. Cure concrete a minimum of 28 days at 75° F before surface preparation, and painting begins. Allow more time at lower temperatures if specified by paint manufacturer.
2. Test concrete for pH and salts using test methods recommended by the paint manufacturer. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer. Do not begin surface preparation, or painting until acceptable to manufacturer.
3. Moisture content of concrete and masonry surfaces shall conform to manufacturer's recommended limits, and as listed in SSPC-SP13/NACE 6 Section 6 Acceptance Criteria Table 1. Floor surfaces to be coated shall be tested in accordance with ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride or as required by the coating manufacturer. Moisture vapor transmission shall not exceed three pounds per 1,000 square feet in a 24-hour period or less if specified by Coating Manufacturer. Vertical and horizontal overhead surfaces shall be tested in accordance with ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete using in situ Probes (relative humidity shall not exceed 80% or as required by the coating manufacturer) or with ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Test Method (test results shall be no moisture present). Engineer or Coating Manufacturer Representative shall specify all test locations. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer.

4. Prepare concrete surfaces to receive coatings in accordance with NACE 6/SSPC-13 – Joint Surface Preparation Standards and ICRI Technical Guidelines. Remove contaminants, open bugholes, surface voids, air pockets, and other subsurface irregularities using abrasive blasting, shot blasting, water jetting or mechanical abrading. Use dry, oil-free air for blasting operations. Surface texture after blasting shall achieve profile as required by manufacturer or where not defined by manufacturer, profile shall be a minimum ICRI-CSP 5 surface profile. Remove residual abrasives, dust, and loose particles by vacuuming or other approved method.
5. Surface defects, such as hollow areas, bugholes, honeycombs, and voids shall be filled with polymeric or waterborne epoxy cementitious filler compatible with painting system. Complete fill coats may be used in addition to specified painting system and as approved by the Engineer. Fins, form marks, and all protrusions or rough edges shall be removed.
6. Repair existing concrete surfaces which are deteriorated to the point that surface preparation exposes aggregate with fill coats or patching mortar as recommended by paint manufacturer and as directed by the Engineer.
7. Clean concrete of all dust, form oils, curing compounds, oil, tar, laitance, efflorescence, loose mortar, and other foreign materials before paints are applied.
8. To ease coating around outside corners, provide $\frac{3}{4}$ -inch chamfered edges on all new concrete outside corners and grind existing concrete outside corners to a minimum radius of $\frac{3}{4}$ -inch.
9. Unless recommended otherwise by the coating manufacturer, provide $\frac{1}{4}$ " deep by $\frac{1}{4}$ " wide tool cut terminations at 1-inch maximum from all coating edges for anchorage. Provide terminations around all equipment, piping, openings, gates, top and bottom of walls, stop locations of each day's work and overlap onto previously completed work. Transition coating 3-inches onto interior lining of piping except where coating compatibility concerns are noted by coating manufacturer.
10. Apply epoxy or polymeric filler compatible with painting system to all inside corners of areas to be coated with a margin trowel to form a continuous 45-degree cant cove across corners with a minimum dimension of 1.5-inch. Roughen or prepare cured filler as recommended by coating manufacturer for proper coating adhesion.
11. All equipment grouting shall be installed and cured prior to starting coating work. Coating shall be applied over grout up to the edges of all equipment, gates and uninterrupted piping unless specifically noted otherwise.

D. Castings

1. Prepare castings for painting by applying a brush or a knife-applied filler. Fillers are not to be used to conceal cracks, gasholes, or excessive porosity.

2. Apply one coat of primer with a minimum thickness of 1.2 mils in addition to coats specified. Allow sufficient drying time before further handling.

E. Masonry

1. Cure for a minimum of 30 days prior to paint application.
2. Clean masonry surfaces free from all dust, dirt, oil, grease, loose mortar, chalky deposits, efflorescence, and other foreign materials.
3. Test masonry for moisture content. Use test method recommended by paint manufacturer. Do not begin painting until moisture content is acceptable to manufacturer.

F. Previously Painted Surfaces

1. Totally remove existing paint when: surface is to be submerged in a severe environment, paint is less than 75% intact, brittle, eroded or has underfilm rusting.
2. Surfaces which are greater than 75% intact require removal of failed paints and then spot primed. Spot priming is in addition to coats specified.
3. Remove surface contamination such as oil, grease, loose paint, mill scale, dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers.
4. Clean and dull glossy surfaces prior to painting in accordance with the manufacturer's recommendations.
5. Check existing paints for compatibility with new paint system. If incompatible, totally remove existing paint system or apply a barrier coat recommended by the paint manufacturer. Remove existing paints of undetermined origin. Prepare a test patch of approximately 3 square feet over existing paint. Allow test patch to dry thoroughly and test for adhesion. If proper adhesion is not achieved remove existing paint and repaint.

3.03 APPLICATION OF PAINT

- A. Apply paint by experienced painters with brushes or other applicators approved by the Engineer, and paint manufacturer.
- B. Apply paint without runs, sags, thin spots, or unacceptable marks.
- C. Apply at rate specified by the manufacturer to achieve at least the minimum dry mil thickness specified. Apply additional coats, if necessary, to obtain thickness.
- D. Special attention shall be given to nuts, bolts, edges, angles, flanges, welds, etc., where insufficient film thicknesses are likely. Stripe paint outside corners and edges in accordance with SSPC PA Guide 11. Stripe painting shall be in addition to coats specified.

- E. Perform thinning in strict accordance with the manufacturer's instructions, and with the full knowledge and approval of the Engineer and paint manufacturer.
- F. Allow paint to dry a minimum of twenty-four hours between application of any two coats of paint on a particular surface, unless shorter time periods are a requirement by the manufacturer. Longer drying times may be required for abnormal conditions as defined by the Engineer and paint manufacturer. Do not exceed manufacturer's recommended drying time between coats.
- G. Suspend painting when any of the following conditions exist:
 - H. Rainy or excessively damp weather.
 - I. Relative humidity exceeds 85%.
 - J. General air temperature cannot be maintained at 50°F or above through the drying period, except on approval by the Engineer and paint manufacturer.
 - K. Relative humidity will exceed 85% or air temperature will drop below 40°F within 18 hours after application of paint.
 - L. Surface temperature of item is within 5 degrees of dewpoint.
 - M. Dew or moisture condensation are anticipated.
 - N. Surface temperature exceeds the manufacturer's recommendations.
- O. Where application of coating across concrete control joints or expansion joints has the potential to crack, turn coating into joints and caulk joints with a sealant compatible with coating rated for the intended service per Section 07 90 00 – Joint Fillers, Sealants, Caulking.

3.04 INSPECTION

- A. Each field coat of paint will be inspected and approved by the Engineer or the Engineer's authorized representative before succeeding coat is applied. Tint successive coats so that no two coats for a given surface are exactly the same color. Tick-mark surfaces to receive black paint in white between coats.
- B. Use magnetic dry film thickness gauges and wet film thickness gauges for quality control. Furnish magnetic dry film thickness gauge for use by the Engineer.
- C. Coatings shall pass a holiday detector test.
- D. Determination of Film Thickness: Randomly selected areas, each of at least 107.5 contiguous square feet, totaling at least 5% of the entire control area shall be tested. Within this area, at least 5 squares, each of 7.75 square inches, shall be randomly selected. Three readings shall be taken in each square, from which the mean film thickness shall

be calculated. No more than 20 percent of the mean film thickness measurements shall be below the specified thickness. No single measurement shall be below 80 percent of the specified film thickness. Total dry film thickness greater than twice the specified film thickness shall not be acceptable. Areas where the measured dry film thickness exceeds twice that specified shall be completely redone unless otherwise approved by the Engineer. When measured dry film thickness is less than that specified additional coats shall be applied as required.

- E. Holiday Testing: Holiday test painted ferrous metal surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Mark areas which contain holidays. Repair or repaint in accordance with paint manufacturer's printed instructions and retest.
- F. Dry Film Thickness Exceeding 20 Mils: For surfaces having a total dry film thickness exceeding 20 mils: Pulse-type holiday detector such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.
- G. Dry Film Thickness of 20 Mils or Less: For surfaces having a total dry film thickness of 20 mils or less: Tinker & Rasor Model M1 non-destructive type holiday detector, K-D Bird Dog, shall be used. The unit shall operate at less than 75-volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo-Flow, shall be added to the water prior to wetting the detector sponge.
- H. Paint manufacturer's NACE certified representative shall provide their services as required by the Engineer. Services shall include, but not be limited to, inspecting existing paint, determination of best means of surface preparation, inspection of completed work, and final inspection of painted work 11 months after the job is completed.

3.05 PROTECTION OF ADJACENT PAINT AND FINISHED SURFACES

- A. Use covers, masking tape, other method when protection is necessary, or requested by Owner or Engineer. Remove unwanted paint carefully without damage to finished paint or surface. If damage does occur, repair the entire surface adjacent to and including the damaged area without visible lapmarks and without additional cost to the Owner.
- B. Take all necessary precautions to contain dispersion of abrasive blasting debris and paint to the limits of the work. Take into account the effect of wind and other factors which may cause dispersion of the abrasive blasting debris and paint. Suspend painting operations when abrasive blasting debris or paint cannot be properly confined. Assume all responsibilities and cost associated with damage to adjacent structures, vehicles, or surfaces caused by the surface preparation and painting operations.

3.06 PIPING AND EQUIPMENT IDENTIFICATION

- A. Piping and equipment identification shall be in accordance with Section 15030 – Piping and Equipment Identification Systems.

3.07 SCHEDULE OF COLORS

- A. Match colors indicated. Piping and equipment colors are indicated in Section 15030 – Piping and Equipment Identification Systems. Colors which are not indicated shall be selected from the manufacturer's full range of colors by the Engineer. No variation shall be made in colors without the Engineer's approval. Color names and numbers shall be identified according to the appropriate color chart issued by the manufacturer of the particular product in question.

3.08 WORK IN CONFINED SPACES

- A. Provide and maintain safe working conditions for all employees. Supply fresh air continuously to confined spaces through the combined use of existing openings, forced draft fans and temporary ducts to the outside, or direct air supply to individual workers. Exhaust paint fumes to the outside from the lowest level in the contained space. Provide explosionproof electrical fans, if in contact with fumes. No smoking or open fires will be permitted in, or near, confined spaces where painting is being done. Follow OSHA, state/commonwealth, and local regulations at all times.

3.09 OSHA SAFETY COLORS

- A. Paint wall around wall-mounted breathing or fire apparatus with the appropriate safety red color; area not to exceed 2 feet wide by 3 feet high, unless apparatus covers the area. Fire apparatus include fire hoses, extinguisher, and hydrants.
- B. Paint hazardous areas and objects in accordance with OSHA regulations.

3.10 VOC REGULATIONS

- A. Provide paint systems in accordance with local, state, and federal regulations. Where paint systems shown in schedule do not comply, substitute equal products with VOC limits which comply with local, state, and federal regulations.

(Continued on Next Page)

Table 1: Painting Schedule

Surface	Application	Painting System and No. of Coats	Product Reference (Table 2)	Total Min. Dry Film Thickness (Mils)
Concrete and Masonry				
Masonry and concrete walls, columns, and beams	All new structures	1 coat sealer 2 coats acrylic epoxy	101 116	75-85 sq.ft./gal. 4-6/coat
Exterior below grade concrete structures	All new structures	2 coats coal tar	107	10
Metals				
Interior and exterior nonsubmerged (gloss)	All new piping, valves, and mechanical equipment, etc.	1 prime coat zinc-rich	104	2.5-3.5
		1 intermediate coat epoxy polyamine	102	5-7
		1 finish coat aliphatic polyurethane	115	3-5
Aluminum surfaces in contact with concrete		2 coats coal tar	107	26
Other				
Interior DIP		1 coat	Protecto 401	40

Table 2: Product Listing

Ref.	System	Purpose	Product			
			Tnemec Series	PPG	CARBOLINE	Sherwin-Williams
101	Acrylic filler	Primer-sealer	130-6601	BLOXFIL 400BF	Sanitile 100	Pro-Industrial Heavy Duty Block Filler
102	Epoxy polyamide	Finish coat semi-gloss or gloss	N69	AMERLOCK 600	Carboguard 893SG	Macropoxy 646
103	Acrylic latex	Sealer	1028/1029	PITT TECH PLUS	Carbocrylic 3359DTM	DTM Acrylic Primer/Finish
104	Zinc-Rich	Primer	90-97	AMERCOAT 68HS	Carbozinc 85	Zinc Clad II Plus (shop) Zinc Clad 4100 (field)
105	Epoxy polyamide	Primer/Finish	L140	AMERLOCK 2 VOC	Carboguard 61/891VOC	Macropoxy 646 PW
106	Coal tar epoxy	Finish high-coat build	46H-413	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
107	Coal tar	Sealer	46-465	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
109	Alkyd-long oil	Finish coat	1029	HP INDUSTRIAL ALKYD 4308	Carbocoat 8215	Industrial Enamel
110	Epoxy polyamide	Primer	66-1211	AMERCOAT 600	Carboguard 893SG	Macropoxy 646
114	Polyamine Epoxy	Intermediate coat	27	AMERLOCK 600	Carboguard 893SG	-
115	Aliphatic Polyurethane	Finish coat	1095	PITTHANE ULTRA 95-812 SERIES	Carbothane 134HG	Acrolon 218HS
116	Acrylic epoxy	Finish coat	113 or 114	AQUAPON WB EP	Sanitile 255	Pro-Industrial Water-Based Catalyzed Epoxy
117	Epoxy block filler	Sealer	1254	AMERLOCK 400BF	Sanitile 500	Kem Cati-Coat HS Epoxy Filler
118	Catalyzed epoxy	Finish coat	84	AMERLOCK 2/400	Carboguard 890	Macropoxy 646
119	High solids epoxy	Finish coat	104	AMERLOCK 240	Carboguard 890	Dura-Plate 235

- END OF SECTION -

SECTION 11000

EQUIPMENT GENERAL PROVISIONS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in acceptable operation all mechanical equipment and all accessories as specified, as shown on the Drawings, and as required for a complete and operable system.
- B. The mechanical equipment shall be provided complete with all accessories, special tools, spare parts, mountings, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation.
- C. The Contractor shall provide the Owner complete and operational equipment/systems. To this end, it is the responsibility of the Contractor to coordinate all interfaces related mechanical, structural, electrical, instrumentation, and control work and to provide necessary ancillary items such as controls, wiring, etc., to make each piece of equipment operational as shown and specified.
- D. The complete installation shall be free from excessive vibration, cavitation, noise, and oil or water leaks.
- E. The requirements of this section shall apply to equipment furnished under Divisions 11 and 15.
- F. Comply with reference specifications, codes and standards as specifically modified, complimented, and supplemented herein.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01090 – Reference Standards along with those identified herein this and other individual specification sections.
- B. American Institute for Steel Construction (AISC)
- C. American National Standards Institute/American Bearing Manufacturers Association (ANSI/ABMA):
 - 1. ANSI/ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings
 - 2. ANSI/ABMA 11 – Load Ratings and Fatigue Life for Ball Bearings

- D. Acoustical Society of America (ASA) / American National Standard Institute (ANSI) S2.75, Shaft Alignment Methodology:
 - 1. Part 1: General Principles, Methods, Practices, and Tolerances
 - 2. Part 2: Vocabulary
 - 3. Part 3: Alignment of Vertically Oriented Rotating Machinery
 - 4. Guidelines and recommendations included in ASA/ANSI S2.75 shall establish and be interpreted as the minimum requirements for acceptance for leveling, grouting and alignment related work.
 - E. American National Standards Institute / American Society of Mechanical Engineers (ANSI/ASME) Standard B29.1, Heavy Duty Offset Sidebar Transmission Roller Chains and Sprocket Teeth.
 - F. American Welding Society (AWS):
 - 1. D1.1 "Structural Welding Code - Steel"
 - 2. D1.2 "Structural Welding Code - Aluminum" of the American Welding Society
 - G. Electrical Apparatus Service Association, Inc. (EASA) Mechanical Reference Handbook (latest revision).
 - H. Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.
 - I. In the event of conflict between individual specifications and reference specifications, codes and standards, the more restrictive criteria shall govern.
- 1.03 ACTION/INFORMATIONAL SUBMITTALS

- A. Product Data:
 - 1. Comply with Section 01300 – Submittals
 - 2. Fabrication information
- B. Provide submittals identified in individual equipment specification sections in addition to the submittals identified herein.
- C. Shop Drawings shall include the following information in addition to the requirements of Section 01300 – Submittals and shall include the following additional information:
 - 1. Equipment name, identification number and specification number.

2. Performance characteristics and descriptive data, including but not limited to capacity, power, speed, torque, and efficiency.
3. Detailed equipment dimensional drawings and setting plans including but not limited to:
 - a. General cutaway sections
 - b. Materials of construction
 - c. Dimension of shaft projections
 - d. Shaft and keyway dimensions
 - e. Shaft diameter
 - f. Shaft connection details
 - g. Dimension between bearings
 - h. General dimensions of equipment
 - i. Anchor bolt locations
 - j. Forces
 - k. Assembly views
 - l. Weights: Provide weight of entire equipment assembly, including motor and base weight of individual major subassemblies. Indicate the weight of each component, and total static and dynamic loads imparted by the equipment to the supporting structure.
 - m. Rotating assembly technical information and illustration.
 - n. Drawings shall identify each component by tag number to which the catalog data and detail sheets pertain.
 - o. Drawings showing the location and type of all equipment, system components, supports, hangers, foundations and the required clearances to operate and maintain equipment, valves and system components in a code compliant, safe and ergonomic manner. Drawings shall show clearances reserved for walking access around all sides, for opening access doors fully, for visual inspection for condition monitoring, and for the performance of maintenance tasks including but not limited to changing filters, replacing belts, maintaining lubrication levels, predictive maintenance and performing diagnostic functions.

4. Drive and motor data as required by Division 16 – Electrical. Complete motor data shall include but not be limited to size, make, type and characteristics along with wiring diagrams. Where equipment and motor speeds are to be regulated by variable speed drives, the Contractor shall coordinate, furnish, and exchange all necessary requirements with the respective equipment manufacturers to ensure compatibility and shall submit equipment, shafting, coupling, motor and variable speed drive shop drawings.
5. Bearings:
 - a. Information on bearings including but not limited to: type, size, materials of construction.
 - b. Bearing life calculations including but not limited to: basic dynamic load rating, static load rating, rating life, ABMA L10 reliability (expressed in hours of bearing life) and bearing system life.
6. Gear box design and performance criteria and AGMA service factor, including but not limited to the following:
 - a. Thermal horsepower rating
 - b. Bearing type
 - c. Actual gear ratio
 - d. Forced lubrication system: Provide description of equipment, system and instrumentation including but not limited to flow meter, pressure switches, etc.
 - e. Gear tooth finish quality
7. Piping schematics.
8. Equipment protective device details and connection diagrams.
9. Panel layout drawings, schematic wiring diagrams, and component product data sheets for control panels.
10. A list of spare parts and special tools to be provided.
11. Information on equipment appurtenances including couplings, shaft guards, v-belt drive systems, etc.
12. Any additional information required to demonstrate conformance with the equipment specifications.
13. Results of critical speed analyses, structural, lateral, and torsional dynamic analyses as required herein and in the individual specification sections.

14. Warranty documentation including statement of duration of warranty period and contact phone numbers and addresses for warranty issues.
15. Shipment, delivery, handling, and storage instructions.
16. Installation instructions
17. Manufacturers literature and brochures
18. Materials of construction and associated specifications (such as AISI, ASTM, SAE, etc.), including grade and type.
19. Anchor design in accordance with Section 05050 – Metal Fastening.
20. Intermediate shafting design, including but not limited to general arrangement drawings, engineering data, materials of construction, recommended angular offsets (for cardan universal jointed shafts), and shaft critical speed analyses (including 1st, 2nd and 3rd critical speed analysis).
21. Coatings: Coating system data and description of coating system, surface preparation and shop painting, including certification that the shop paint is compatible with the finish paint.
22. Pre-commissioning lubrication oil flushing plan developed by a machinery lubrication specialist, specifically for each piece of lubricated equipment. Plan shall identify, describe procedure, and demonstrate data-based approach to demonstrating achievement of lubricant cleanliness via flushing. Level of lubricant cleanliness shall be as required by equipment manufacturer's written recommendations.
23. Equipment installation lists.
24. Equipment specific requirements for levelness, plumbness, flatness, coplanarity and coplanar surface deviation.

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
 1. Section 01300 – Submittals
 2. Section 01600 – Materials and Equipment
- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01300 – Submittals and Section 01520 – Maintenance of Utility Operations During Construction.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:
 - 1. Section 01300 – Submittal Procedures
 - 2. Section 01520 – Maintenance of Utility Operations During Construction
- B. Comply with Section 01600 – Materials and Equipment:
 - 1. For spare parts, extra stock materials, and tools, submit quantity of items specified in associated Specification Section.
 - 2. Submit complete list of spare parts, extra stock materials, maintenance supplies and special tools required for maintenance for one year with unit prices and source of supply. Indicate number/quantity specified and furnished, manufacturer, part number, description,
- C. Comply with Section 01730– Operations and Maintenance Data.
- D. Lubrication Information:
 - 1. Comply with Specification Section 01520 – Maintenance of Utility Operations During Construction.
 - 2. Complete lubrication instructions and lubricant schedule, including manufacturer's recommended lubricant. Schedule shall include frequency of lubricant application, type of lubricant, and instructions regarding lubricant application.

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Factory testing plan.
- B. Factory Test Results shall be submitted and approved prior to shipment of equipment.
- C. Field testing plan.
- D. Comply with Section 01650 – Checkout and Startup Procedures.
- E. Alignment Report:
 - 1. Alignment reports shall contain numerical values to express offset and angular alignment and all other parameters documented in ANSI/ASA S2.75.
 - 2. Alignment reports shall be submitted immediately after each of the following activities have been completed:
 - a. Preliminary Alignment

- b. Final Alignment (at both ambient and operating temperatures)
 - c. Re-check of alignment
- F. Preliminary field test data
- G. System field quality control testing
- H. Final field test data
- I. Certified test reports

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. All parts of the equipment furnished shall be designed and constructed for the maximum stresses occurring during fabrication, transportation, installation, testing, and all conditions of operation. All materials shall be new and shall conform to all applicable Sections of these Specifications.
- B. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.
- C. Equipment and appurtenances shall be designed in conformity with specifications, codes and reference standards.
- D. All bearings and moving parts shall be protected by bushings or other Engineer approved means against wear, and provision shall be made for accessible lubrication by extending lubrication lines and fittings to approximately 30 inches above finished floor elevation.
- E. Details shall be designed for appearance as well as utility. Protruding members, joints, corners, gear covers, etc., shall be finished in appearance. All exposed welds on machinery shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.
- F. Machinery parts shall conform within allowable tolerances to the dimensions shown on the working drawings.
- G. All machinery and equipment shall be safeguarded in accordance with the specifications, codes, and reference standards.
- H. All rotating shafts, couplings, or other moving pieces of equipment shall be provided with protective guards of sheet metal or wire mesh, neatly and rigidly supported. Guards shall be removable as required to provide access for repairs.
- I. All equipment greater than 100 pounds shall have lifting lugs, eyebolts, etc., for ease of lifting, without damage or undue stress exerted on its components.

- J. All manufactured items provided under this Section shall be of current manufacture and shall be the products of manufacturers specializing in the manufacture of such products.
- K. Code Compliance, safety and ergonomics for operating and maintenance personnel accessing equipment shall be considered during shop drawing development, fabrication, and installation. Items to consider include but are not limited to clearances reserved for walking access around all sides, for opening access doors fully, for visual inspection for condition monitoring, and for the performance of maintenance tasks including but not limited to changing filters, replacing belts, maintaining lubrication levels, predictive maintenance and performing diagnostic functions.

1.08 EQUIPMENT WARRANTIES

- A. Warranty requirements shall be as specified in Section 01600 – Materials and Equipment and Section 01650 – Checkout and Startup Procedures. Warranty requirements are supplementary to the individual equipment specifications. In the event of conflicts, the most stringent requirement shall apply.
- B. Warrant that equipment is free of defects in materials and workmanship for a minimum period of one year following substantial completion. Warranty shall include parts, labor, travel, and shipping at no additional cost to the owner.
- C. Extended warranties shall be as specified in individual equipment section.

1.09 DEFINITIONS

- A. Comply with specification Section 01090 – References.
- B. Refer to the specified reference specifications, codes, and standards for definitions applicable to this specification. Additional definitions are included hereafter.
- C. Chockplate: A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of a machinery structural steel base plate.
- D. Equipment Train: Two or more rotating equipment machinery elements consisting of at least one driver and one driven element joined together by a coupling.
- E. Mounting plate: A device used to attach equipment to concrete foundations; includes base plates, soleplates, and chockplates. A mounting plate is a base-support mechanism for the attached machinery and all individual pieces of machinery are expected to be removable from the mounting plate as a single assembly.
- F. Operating Temperature (Thermal) Alignment: A procedure to determine the actual change in relative shaft positions within a machinery train from the ambient (not running) condition and the normal operating temperature (running) condition by taking measurements from start-up to normal operating temperature while the machine(s) is (are) operating, or after the shafts have been stopped but the machines are still near operating temperature.

- G. Preliminary alignment: The aligning of two adjacent machinery shafts to ensure that final alignment can be achieved without being bolt bound. This is accomplished before grouting (for horizontal machines) and the measurement of piping strain on the machinery.
- H. Soleplate: A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of machinery.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All like components within a piece of equipment shall be provided by the same manufacturer.
- B. Base plates:
 - 1. Top surface of mounting plates shall be machined in locations where equipment supports/feet will contact the plate.
 - 2. Equipment contact points shall be flat and parallel within ASA/ANSI 2.75 tolerances or 0.002-inches per foot, whichever is more stringent, and within related tolerances.
 - 3. There shall be no paint where equipment supports or feet contact mounting plate.
 - 4. Mounting plate shall be sufficiently rigid to avoid bending or flexing when equipment is installed.

2.02 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 - 1. Specification Section 05050 – Metal Fastening.
 - 2. Comply with individual equipment specifications.
- B. The Contractor shall furnish, install, and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of the devices included in the equipment specified. Working Drawings for installation shall be furnished by the equipment manufacturer, and templates shall be used by the Contractor when required in the detailed equipment Specifications.
- C. Anchor bolts and fasteners:
 - 1. Anchor bolts shall be designed and provided by the Contractor in accordance with Section 05050 – Metal Fastening, and with the individual equipment Specifications.

2. All anchor bolts shall have at least the minimum diameter as required by Specification Section 05050 – Metal Fastening.
 3. All anchor bolts, guard bolts, washers, clips, clamps, fasteners, and leveling plate pads, nuts, shims, and jack bolts of any type shall be constructed of 316 stainless steel, unless otherwise specified the individual equipment Specifications.
 4. Undercutting of anchors or fasteners shall not be permitted.
- D. Pipe sleeves as a means for adjusting anchor bolts shall be provided where indicated in the contract documents or required by the equipment manufacturer.
 - E. The Contractor shall provide all concrete pads or pedestals required for equipment furnished. All concrete equipment pads shall be a minimum of 4" high, unless otherwise shown on the Drawings, and shall be doweled.

2.03 DEFAULT MATERIALS

- A. Equipment shall be constructed out of the materials specified in respective individual pumping specification sections. Material not specifically called for shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended.

2.04 STRUCTURAL STEEL

- A. Structural steel used for fabricating equipment shall conform to the requirements of Section 05500 – Metal Fabrications.
- B. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

2.05 DISSIMILAR METALS

- A. All dissimilar metals shall be isolated in accordance with Section 05010 – Metal Materials and to the satisfaction of the Engineer.

2.06 STANDARDIZATION OF GREASE FITTINGS

- A. The grease fittings on all mechanical equipment shall be such that they can be serviced with a single type of grease gun. Fittings shall be "Zerk" type.

2.07 ELECTRICAL REQUIREMENTS

- A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit, and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 16 specifications and the latest National Electric Code. Motor starters and controls shall be furnished and installed under Division 15 and Division 16 unless otherwise specified in the individual equipment specifications.

- B. In the individual equipment specifications, specified motor horsepower is intended to be the minimum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.
- C. Where variable frequency drives (VFDs) are specified, the Contractor shall be responsible for coordinating between equipment supplier and VFD supplier to ensure a complete and operational system. VFDs shall be furnished under Division 16 unless otherwise specified in the equipment specification. Wherever variable speed drives (VSDs) are specified the same requirements as for VFDs shall apply.
- D. Motor starters and controls shall be furnished and installed under Division 15 and Division 16 unless otherwise specified in the individual equipment specifications.

2.08 ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS

- A. Accessories, spare parts, and special tools shall be provided in accordance with Section 01600 – Materials and Equipment.

2.09 EQUIPMENT IDENTIFICATION

- A. All mechanical equipment shall be provided with a substantial stainless-steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with:
 - 1. The manufacturer's name
 - 2. Year of manufacture
 - 3. Serial number
 - 4. Principal rating data such as (for example):
 - a. Capacity
 - b. Pressure
 - c. Horsepower
 - d. Speed
- B. Each piece of mechanical equipment shall also be identified as to name and number by a suitable laminated plastic or stainless-steel nameplate mechanically fastened with stainless steel hardware; for example, "Raw Water Pump #1 (RWP-1)". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.

- C. Nameplates shall not be painted over.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. All equipment shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and that it will operate in the manner specified or implied.
- B. No equipment shall be shipped to the project site until the Engineer has been furnished a certified copy of test results and has notified the Contractor, in writing, that the results of such tests are acceptable.
- C. A certified copy of the manufacturer's actual test data and interpreted results thereof shall be forwarded to the Engineer for review.
- D. If required by the individual equipment Specifications, arrangements shall be made for the Owner/Engineer to witness performance tests in the manufacturer's shop. The Engineer shall be notified ten working days before shop testing commences. Expenses are to be paid by Contractor.
- E. Shop testing of electric motors shall conform to:
 - 1. Section 16150 – Low-Voltage Electric Motors
 - 2. Section 16000 – Basic Electrical Requirements

3.02 SHIPMENT, DELIVERY, HANDLING, AND STORAGE

- A. Shipment, delivery, and handling of equipment and materials shall be in accordance with Section 01600 – Materials and Equipment.
- B. Storage of equipment and materials shall be in accordance with Section 01600 – Materials and Equipment.
- C. Shipping plans shall include consideration for protecting bearings and/or other rotating equipment from chatter damage.
- D. Any equipment shipped to site that needs further attention shall have a WARNING tag affixed to it with indication of the action that should be taken in preparation for startup. Examples are: Final Lubrication, Mechanical Seal not in final position, etc.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Manufacturer's field services shall be in accordance with Section 01650 – Checkout and Startup Procedures.

- B. The Contractor shall arrange for a qualified factory trained Technical Representative from each manufacturer or supplier of equipment who is regularly involved in the inspection, installation, start-up, troubleshooting, testing, maintenance, and operation of the specified equipment. Qualification of the Technical Representative shall be appropriate to the type of equipment furnished and subject to the approval of the Engineer and the Owner. Where equipment furnished has significant process complexity, furnish the services of engineering personnel knowledgeable in the process involved and the function of the equipment. When necessary, the Contractor shall schedule multiple Technical Representatives to be present at the same time for the purpose of coordinating the operation of multiple pieces of related equipment.
- C. Services of the Technical Representative will require a minimum of two (2) site visits, one for installation and testing and one for startup, and will be for the minimum number of days recommended by the manufacturer and approved by the Engineer but will not be less than the number of days specified in individual equipment sections. Additional site visits may be required as described below and in the equipment specifications.
- D. For each site visit, the Technical Representative shall submit jointly to the Owner, the Engineer, and the Contractor a complete signed report of the results of their inspection, operation, adjustments, and testing. The report shall include detailed descriptions of the points inspected, tests and adjustments made, quantitative results obtained if such are specified.
- E. The manufacturer's Technical Representative shall provide the following services.
 - 1. Installation: The Technical Representative shall inspect the installed equipment to verify that installation is in accordance with the manufacturer's requirements. Where required by individual equipment specifications, the Technical Representative shall also supervise the installation of the equipment.
 - 2. Testing: After installation of the equipment has been completed and the equipment is presumably ready for operation, but before it is operated by others, the Technical Representative shall inspect, operate, test, and adjust the equipment as required to prove that the equipment is in proper condition for satisfactory operation under the conditions specified. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for startup and that nothing in the installation will render the manufacturer's warranty null and void. The report shall include date of final acceptance field test, as well as a listing of all persons present during tests.
 - 3. Startup: The Technical Representative shall start up the equipment for actual service with the help of the Contractor. If equipment or installation problems are experienced, the Contractor and the representative shall provide the necessary services until the equipment is operating satisfactorily and performing according to the specifications at no additional cost to the Owner. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for permanent operation

and that nothing in the installation will render the manufacturer's warranty null and void.

4. Training: Training shall be provided in accordance with Section 01730 – Operations and Maintenance Data.
 5. Services after Startup: Where required by the individual equipment specifications, the Technical Representative shall return to the project site thirty (30) days after the startup date to review the equipment performance, correct any equipment problems, and conduct operation and maintenance classes as required by the Owner. This follow-up trip is required in addition to the specified services of Technical Representative prior to and during equipment startup. At this time, if there are no equipment problems, each manufacturer shall certify to the Owner in writing that their equipment is fully operational and capable of meeting operating requirements. If the equipment is operating incorrectly, the Technical Representative will make no certification to the Owner until the problems are corrected and the equipment demonstrates a successful thirty (30) days operating period.
- F. The Contract amount shall include the cost of furnishing the Technical Representative for the minimum number of days specified, and any additional time required to achieve successful installation and operation. The times specified for services by the Technical Representative in the equipment Specifications are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.
- G. The Contractor shall notify the Engineer at least 14 days in advance of each equipment test or Owner training session.
- H. The Technical Representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day the Technical Representative is at the project.

3.04 INSTALLATION

- A. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation. Equipment shall be installed strictly in accordance with recommendations of the manufacturer. A copy of all installation instructions shall be furnished to the Engineer's field representative one week prior to installation.
- B. The Owner's field representative (e.g., the Engineer or similar) shall witness all activities involved with equipment installation.
- C. The Contractor shall have on hand personnel, construction equipment, and machinery of capacity to facilitate the work and to handle all emergencies encountered in work of this character. To minimize field erection problems, mechanical units shall be factory assembled insofar as practical.

- D. Equipment shall be erected in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Drawings.
- E. All equipment sections and loose items shall be match-marked prior to shipping.
- F. The Contractor shall furnish oil and grease for initial operation and testing. The manufacturer and grades of oil and grease shall be in accordance with the recommendations of the equipment manufacturer.
- G. Leveling and Grouting:
 - 1. Set equipment to dimensions shown on drawings. Dimensions shall be accurate to $\pm 1/16$ inch except as otherwise specified, required, or indicated on the drawings.
 - 2. Base plate Surface Preparation – Prior to setting equipment and grouting, inspect and clean equipment mounting base plates, pads, feet, and frames to remove all grease, rust, paint, and dirt.
 - 3. Wedges (i.e., tapered shims) shall not be used for leveling, aligning, or supporting equipment.
 - 4. General Equipment Leveling:
 - a. Non-rotating Equipment: Set level to $\pm 1/16$ inch per 10-foot length (0.005 inch per foot) unless manufacturer's requirements are more stringent.
 - b. Rotating Equipment: Install, set to the most stringent of the following requirements for levelness, plumbness, flatness, coplanarity and coplanar surface deviation:
 - 1) ASA-ANSI S2.75, Shaft Alignment Methodology. Comply with tolerance ranges scheduled at the end of this specification section.
 - 2) Individual equipment specifications
 - 3) Manufacturer's pre-printed written requirements.
 - c. Shims or leveling nuts shall be used unless equipment is furnished with leveling feet. Set shims flush with equipment base plate edges. When grouting is required, equipment shall be shimmed to allow a minimum of one-inch grout thickness. Grout shall cover shims at least 3 inches. Final level check shall be held for inspection and approval by Engineer before proceeding.
 - d. Equipment shall be leveled by first using sitting nuts on the anchor bolts, and then filling the space between the equipment base and concrete pedestal with epoxy base plate grout, unless alternate methods are recommended by the manufacturer and are acceptable to the Engineer (e.g., such as shim leveling pumps, or chemical grout).

3.05 ALIGNMENT

- A. For equipment that requires field alignment and connections, the Contractor shall provide the services of the manufacturer's qualified mechanic, millwright, or machinist, to align the equipment and motor prior to making piping connections or anchoring the equipment base. Alignment shall be as specified herein.
- B. Rotating Equipment Shaft Alignment: Assembled equipment shafts shall be set to comply with the most stringent of the following tolerance requirements for shaft runout and shaft-to-shaft alignment tolerances expressed in angle at flex plane, in offset and angularity and/or in offset per tolerance plane separation:
 - 1. ASA-ANSI S2.75, Shaft Alignment Methodology. Comply with tolerance ranges scheduled at the end of this specification section.
 - 2. Individual equipment specifications
 - 3. Manufacturer's pre-printed written requirements.
- C. Use the machined surfaces on which the equipment sets for the base/mounting frame leveling plane. Use the machined shaft surface for equipment leveling plane.
- D. Sprocket and Sheave Alignment:
 - 1. Check shaft mounted components for face runout and eccentricity (outside diameter) runout by magnetically mounting a dial indicator on a stationary base and indicating over 360 degrees on a continuous machined surface at the outside diameter of the component. Maximum allowable total indicated face runout and eccentricity for sprockets and sheaves will be per ANSI Standard B29.1-1975.
 - 2. Drive and driven sheaves shall lie in the same plane. The sum of parallel and angular sheave misalignment measured across the span length of the belt and angular misalignment perpendicular to the belt span length shall each not exceed ½ degree or the belt manufacturer's recommendation whichever is more stringent.
- E. Belt tensioning: Set drive belt tension to manufacturer's specification for the belt type. Recheck alignment after drive tensioning.
- F. Thermal/Mechanical Growth: Thermal/mechanical growth corrections for driver and driven machines will be used in vertical and horizontal alignment where applicable. The equipment manufacturer will determine thermal/mechanical growth applicability for any machine and provide the correction offsets to be used.
- G. Rotating Shaft Alignment
 - 1. Measurement devices/fixtures will be set up on the driver and driven machine, or machine shaft surfaces. Machined coupling hubs may be used only if there is no clearance to mount fixtures directly on the shafts.

2. Account for possible coupling flex by always rotating coupled machines in the same direction during alignment.
3. Final alignments shall be performed utilizing laser alignment tools unless otherwise approved by the Engineer.
4. Alignment Steps: Each of the following alignment steps are required in all instances, including but not limited to, all vertically and horizontally mounted drivers:
 - a. Preliminary alignment is when uncoupled. Preliminary Alignment (at ambient temperature):
 - 1) Perform prior to grouting and piping connections.
 - 2) Check shaft straightness (runout).
 - 3) Correct for soft foot.
 - b. Final alignment method is when coupled. Final Alignment (at ambient temperature):
 - 1) Perform after grouting and piping connections have been completed.
 - 2) Check for pipe strain.
 - 3) Alignment shall be within tolerances.
 - c. Final alignment method is when coupled. Final Alignment (at operating temperature after 1-hour of continuous operation):
 - 1) Check for pipe strain.
 - 2) Alignment shall be within tolerances (coupled).
 - d. Re-check alignment (at operating temperature):
 - 1) After a minimum of 24-hours of run time
 - 2) Alignment shall be within tolerances (coupled)

3.06 FIELD TESTING

- A. Field testing shall be in accordance with Section 01650 – Checkout and Startup Procedures.
- B. All equipment shall be set, aligned, and assembled in conformance with the manufacturer's drawings and instructions. Provide all necessary calibrated instruments to execute performance tests. Submit report certified by the pump manufacturer's representative.

C. Preliminary Field Tests, Yellow Tag.

1. As soon as conditions permit, after the equipment has been secured in its permanent position, the Contractor shall:
 - a. Verify that the equipment is free from defects.
 - b. Check for alignment as specified herein.
 - c. Check for direction of rotation.
 - d. Check motor for no load current draw.
2. Contractor shall flush all bearings, gear housings, etc., in accordance with the pre-commissioning lubrication oil flushing plan and manufacturer's pre-printed written recommendations, to remove any foreign matter accumulated during shipment, storage or erection. Lubricants shall be added as required by the manufacturer's instructions.
3. When the Contractor has demonstrated to the Engineer that the equipment is ready for operation, a yellow tag will be issued. The tag will be signed by the Engineer, or the Engineer's assigned representative and attached to the equipment. The tag shall not be removed.
4. Preliminary field tests, yellow tag, must be completed before equipment is subjected to final field tests, blue tag.

D. Final Field Tests, Blue Tag

1. Upon completion of the above, and at a time approved by the Engineer, the equipment will be tested by operating it as a unit with all related piping, ducting, electrical and controls, and other ancillary facilities.
2. The equipment will be placed in continuous operation as prescribed or required and witnessed by the Engineer or the Engineer's assigned representative and the Owner or the Owner's assigned representative.
3. The tests shall prove that the equipment and appurtenances are properly installed, meet their operating cycles and are free from defects such as overheating, overloading, and undue vibration and noise. Operating field tests shall consist of the following:
 - a. Check equipment for excessive vibration and noise.
 - b. Check motor current draw under load conditions. The rated motor nameplate current shall not be exceeded. The rated motor nameplate horsepower shall not be exceeded when a torque transducer is provided.

- c. Recheck alignment where applicable, after unit has run under load for a minimum of 24 hours.
- E. Additional field testing recommended by the manufacturer shall be performed at no cost to Owner.
- F. Until final field tests are acceptable to the Engineer, the Contractor shall make all necessary changes, readjustments, and replacements at no additional cost to the Owner.
- G. Upon acceptance of the field tests, a blue tag will be issued. The tag will be signed by the Engineer and attached to the unit. The tag shall not be removed, and no further construction work will be performed on the unit, except as required during start-up operations and directed by the Engineer.
- H. Defects which cannot be corrected by installation adjustments will be sufficient grounds for rejection of any equipment.
- I. All costs in connection with field testing of equipment such as lubricants, temporary instruments, labor, equipment, etc., shall be borne by the Contractor. Power, fuel, chemicals, water, etc. normally consumed by specific equipment shall be supplied by the Owner unless otherwise specified in the individual equipment specifications.
- J. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.
- K. Field testing of electric motors shall be in accordance with Section 16150– Low-Voltage Electric Motors, and Section 16000 – Basic Electrical Requirements.

3.07 VIBRATION TESTING

- A. Vibration testing shall be in accordance with Section 01650 – Checkout and Startup Procedures, individual equipment specification, and per manufacturer's recommendation.

3.08 FAILURE OF EQUIPMENT TO PERFORM

- A. Any defects in the equipment, or failure to meet the guarantees or performance requirements of the Specifications shall be promptly corrected by the Contractor by replacements or otherwise.
- B. If the Contractor fails to make these corrections, or if the improved equipment shall fail again to meet the guarantees or specified requirements, the Owner, notwithstanding their having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at the Contractor's expense.
- C. The Contractor shall then obtain specified equipment to meet the contract requirements or upon mutual agreement with the Owner, adjust the contract price to reflect not supplying the specific equipment item.

- D. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates or otherwise on account of the lump sum prices herein specified.
- E. Upon receipt of said sums of money, the Owner will execute and deliver to the Contractor a bill of sale of all rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises until the Owner obtains from other sources other equipment to take the place of that rejected.
- F. Said bill of sale shall not abrogate Owner's right to recover damages for delays, losses, or other conditions arising out of the basic contract.

3.09 PAINTING

- A. The equipment and motor shall be painted. All surface preparation, shop painting, field repairs, finish painting, and other pertinent detailed painting specifications shall conform to applicable paragraphs of Section 09900 – Painting.
- B. All shop coatings shall be compatible with proposed field coatings.
- C. All inaccessible surfaces of the equipment, which normally require painting, shall be finished painted by the manufacturer.
- D. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

3.10 WELDING

- A. The Equipment Manufacturer's shop welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- B. The Contractor's welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- C. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer's drawings regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society, and special conditions, as shown by notes and details.

Schedule 11000 – 01 – Applicable Tolerance Range

Equipment Horsepower	ANSI/ASA S2.75 Quality Grade Tolerance Range
<= 25 HP	Minimal
> 25 HP < 100 HP	Standard
> = 100 HP	Precision

Scheduled ANSI/ASA S2.75 Quality grade tolerance range categories relate to ANSI/ASA S2.75 quantified tolerances for: levelness, plumbness, flatness, coplanarity, coplanar surface deviation, shaft runout, shaft-to-shaft alignment, flex plane offset, angularity, and offset per tolerance plane separation.

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SECTION 11100

PUMPS – GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Comply with the requirements of Section 11000 – Equipment General Provisions.
- B. Pumps shall be provided complete with all accessories, special tools, spare parts, mountings, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation.
- C. The provisions of this section shall apply to all pumps and pumping equipment specified except where specifically noted otherwise in the Contract Documents.
- D. All pumps provided under an individual specification section shall be by the same manufacturer unless otherwise indicated in the specification.
- E. All equipment for the pumps, including but not limited to motors, cans and bases, shall be provided as a complete unit by the pump Manufacturer.
- F. The pump supplier shall have unit responsibility for coordinating the proper pump mounting system with the Contractor to ensure stable pump operation free from abnormal vibration.
- G. The pump supplier shall include, in their bid, time, labor, materials and tools required for installation assistance, testing and start-up with the Contractor.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01090 – Reference Standards.
- B. Pumping system equipment, installation and testing shall be in accordance with the following applicable codes, standards, and guidelines. All codes, standards and guidelines shall be the latest version as of the date of project bidding.
 - 1. American National Standards Institute / Hydraulic Institute (ANSI/HI)
 - a. ANSI/HI 3.1-3.5 Rotary Pumps for Nomenclature, Definitions, Application and Operation
 - b. ANSI/HI 3.6 Rotary Pump Test
 - c. ANSI/HI 9.6.1 Rotodynamic Pumps – Guideline for NPSH Margin

- d. ANSI/HI 9.6.2 Rotodynamic Pumps for Assessment of Applied Nozzle Loads
 - e. ANSI/HI 9.6.3 Rotodynamic Pumps – Guideline for Operating Regions
 - f. ANSI/HI 9.6.4 Rotodynamic Pumps for Vibration Measurements and Allowable Values
 - g. ANSI/HI 9.6.5 Rotodynamic Pumps Guideline for Condition Monitoring
 - h. ANSI/HI 9.6.6 Rotodynamic Pumps for Pump Piping
 - i. ANSI/HI 9.6.8 Rotodynamic Pumps - Guideline for Dynamics of Pumping Machinery. Guidelines and recommendations included in ANSI/HI 9.6.8 shall constitute the minimum requirements for acceptance.
 - j. ANSI/HI 9.8 Rotodynamic Pumps for Pump Intake Design
 - k. ANSI/HI 11.6 Rotodynamic Submersible Pumps for Hydraulic Performance, Hydrostatic Pressure, Mechanical and Electrical Tests
 - l. ANSI/HI 12.1-12.6 Rotodynamic Slurry Pump for Nomenclature, Definitions, Applications and Operation
 - m. ANSI/HI 14.1-14.2 Rotodynamic Pumps for Nomenclature and Definitions
 - n. ANSI/HI 14.3 Rotodynamic Pumps for Design and Application
 - o. ANSI/HI 14.6 Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
- 2. American Society of Mechanical Engineers (ASME)
 - a. ANSI/ASME B73.1 Specifications for Horizontal End Suction Centrifugal Pumps for Chemical Process
 - 3. American Petroleum Institute (API)
 - a. ANSI/API Standard 610 Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
 - 4. American Water Works Association (AWWA)
 - a. ANSI/AWWA E103 Standard for Horizontal and Vertical Line-Shaft Pumps
 - 5. American Society for Testing and Materials (ASTM)
 - a. A36 Specification for Structural Steel
 - b. A48 Specification for Gray Iron Castings

- c. A53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - d. A148 Specification for Steel Castings, High Strength, for Structural Purposes
 - e. A193 Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
 - f. A276 Specification for Stainless Steel Hot/Cold-Finished Bars
 - g. A322 Specification for Steel Bars, Alloy, Standard Grades
 - h. A514 Specification for High Yield Strength, Quenched and Tempered alloy Steel Plate, Suitable for Welding
 - i. A532 Specification for Abrasion-Resistant Cast Irons
 - j. A536 Specification for Ductile Iron Castings
 - k. A565 Specification for Martensitic Stainless Steel Bars
 - l. A582 Specification for Free-Machining Stainless and Heat-Resisting Steel Bar, Hot-Rolled and Cold-Rolled
 - m. A743 Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel and Nickel-Base, Corrosion-Resistant for General Application
 - n. B148 Specification for Aluminum-Bronze Sand Castings
 - o. B584 Specification for Copper Alloy Sand Castings for General Application
- 6. American National Standards Institute (ANSI)
 - a. B16.1 Standard for Cast Iron Pipe Flanges and Flanged Fittings
 - b. B16.5 Standard for Pipe Flanges and Flanged Fittings
 - 7. American National Standards Institute / National Fire Protection Association (ANSI/NFPA) 70 National Electric Code
 - 8. Society of Automotive Engineers (SAE) J404 Chemical Compositions of SAE Alloy Steels
 - 9. International Organization for Standardization (ISO), Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.
 - 10. Comply with the requirements of Section 11000 – Equipment General Provisions.

C. Related contract specification sections:

1. Section 01300 – Submittals
2. Section 11000 – Equipment General Provisions
3. Division 15 – Mechanical
4. Division 16 – Electrical

1.03 ACTION/INFORMATIONAL SUBMITTALS

A. Product Data:

1. Comply with Section 01300 – Submittals.
2. Fabrication information

B. Provide submittals identified in Specification Section 11000 – Equipment General Provisions in addition to the submittals identified herein and in addition to the submittals identified in the individual pumping specification sections.

C. Shop Drawings shall include the following information in addition to the requirements of Section 01300 – Submittals and shall include the following information in addition to the requirements of Section 01300 – Submittals:

1. Pump name, identification number and specification number.
2. Performance characteristics and descriptive data, including but not limited to:
 - a. Pump performance curves at rated speed and reduced speeds (if reduced speeds are specified).
 - b. Pump performance data shall be provided for the proposed impeller diameter and for the maximum impeller diameter possible with the proposed pump.
 - c. Curves shall indicate:
 - 1) Information specified elsewhere
 - 2) Impeller diameter
 - 3) Minimum continuous stable flow (minimum flow to avoid suction recirculation)
 - 4) Preferred operating region (POR) per ANSI/HI 9.6.3
 - 5) Allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.

- 6) Performance curves submitted shall be for the entire pump assembly, including efficiency corrections and losses.
- 7) Pump performance curves shall be submitted both in the form of performance data cut sheets and in tabular format. Tabular data shall include the following:
 - a) Flow
 - b) Pump Head (pressure for positive displacement type pumps)
 - c) NPSH required (Net positive inlet pressure, NPIP, for positive displacement type pumps)
 - d) Pump Efficiency
 - e) Pump horsepower
 - f) Brake horsepower
 - g) A minimum of 10 data points shall define rotodynamic pump performance curves listed above. Performance curve data points shall include the following:
 - i. best efficiency point
 - ii. all specified operating points
 - iii. preferred operating range minimum and maximum
 - iv. allowable operating range minimum and maximum
 - v. shutoff condition
 - vi. runout.
 - vii. The remainder of the points shall be distributed evenly to clearly define the shape of each of the curves.
 - viii. Each data point shall be reported to a minimum of three (3) significant figures.
 - ix. The curve data shall align with the HI acceptance grade (1B, 2B, 1U, etc.) as specified in the individual pump specification and shall explicitly state the applicable tolerance band, as defined by the Hydraulic Institute Standards, associated with each value.

3. Minimum submergence requirements shall be provided for vertically suspended pumps and submersible pumps.
4. Detailed dimensional drawings, data and setting plans including but not limited to:
 - a. General cutaway sections
 - b. Materials
 - c. Dimension of shaft projections
 - d. Shaft and keyway dimensions
 - e. Shaft diameter
 - f. Shaft-impeller connection details
 - g. Dimension between bearings
 - h. General dimensions of pump
 - i. Suction head bolt orientation
 - j. Anchor bolt locations
 - k. Forces: Itemized forces shall be determined at specified operating points and at pump shutoff condition.
 - l. Assembly views
 - m. Exploded parts view
 - n. Cutaway images
 - o. Provide weight of entire pump assembly, including motor and base weight of individual major subassemblies. Indicate the weight of each component, and total static and dynamic loads imparted by the equipment to the supporting structure. Itemized loads shall be determined at specified operating points and at pump shutoff condition.
 - p. Impeller
 - q. Drawings shall identify each component by tag number to which the catalog data and detail sheets pertain.
 - r. mass of rotating assembly
 - s. mass of coupling(s)

5. Drive and motor data as required by Division 16 – Electrical. Complete motor data shall include but not be limited to:
 - a. Size
 - b. make
 - c. mass of motor
 - d. inertia of driver
 - e. motor enclosure type
 - f. characteristics
 - g. wiring diagrams.
 - h. Variable speed drive information and data: Where pump and motor speeds are to be regulated by variable speed drives, the Contractor shall coordinate, furnish and exchange all necessary requirements with the respective equipment manufacturers to ensure compatibility and shall submit pump, motor and variable speed drive shop drawings together as a complete system.
6. Information on pumps and motor bearings, including but not limited to:
 - a. bearing types
 - b. rated bearing life
 - c. bearing life calculations for the specified operating points.
 - d. bearing arrangement
7. Gear box design and performance criteria and AGMA service factor.
8. Equipment protective device details and connection diagrams.
9. Details of shaft sealing system including seal/packing type, seal water/cooling water control devices, and seal water/cooling water piping schematic.
10. Information on pump appurtenances including but not limited to:
 - a. Couplings
 - b. shaft guards
 - c. v-belt drive systems

11. Submersible pump submittals shall also include:
 - a. Product data sheets for power and control cables, length of cables and cable support system.
 - b. Details on pump guide rail system and mounting requirements.
 - c. Details on submersible pump's retrieval system.
 12. Any additional information required to demonstrate compliance with the specifications.
- D. Results of structural, lateral, and torsional dynamic analyses as required herein and in the individual specification sections.
- E. Manufacturers literature and brochures
- F. Lubrication Information: Complete lubrication instructions and lubricant schedule, including manufacturer's recommended lubricant. All lubricants shall be food grade, NSF 61 approved. Schedule shall include frequency of lubricant application, type of lubricant, and instructions regarding lubricant application. Comply with Section 11000 – Equipment General.
- G. Materials of construction data and associated specifications (such as AISI, ASTM, SAE, etc.), including but not limited to:
1. grade
 2. type
 3. elemental makeup, by percent elemental constituent
 4. mechanical properties, including but not limited to:
 - a. Brinell hardness number
 - b. galling resistance
- H. Coatings: Coating system data and description of coating system, surface preparation and shop painting, including certification that the shop paint is compatible with the finish paint.
- 1.04 CLOSEOUT SUBMITTALS
- A. Submit warranty documentation in compliance with:
1. Section 01300 – Submittals
 2. Section 01600 – Materials and Equipment

3. Section 01650 – Checkout and Startup Procedures

- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01300 – Submittals and Section 01730 – Operation and Maintenance Data.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:

1. Section 01300 – Submittals.
2. Section 01730– Operation and Maintenance Data.
3. Comply with Section 01600 – Materials and Equipment.

- B. Comply with Section 01730– Operation and Maintenance Data.

- C. Comply with Section 11000 – Equipment General Provisions.

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Factory testing plan.
- B. Factory Test Results shall be submitted and approved prior to shipment of equipment.
- C. Shipment, Delivery, Handling and Storage instructions.
- D. Installation instructions.
- E. Field testing plan.
- F. Comply with Section 01650 – Checkout and Startup Procedures.
- G. Preliminary field test data.
- H. System field quality control testing
- I. Final field test data.
- J. Certified test reports
- K. Startup report including data substantiation of successful completion of 30-day operational demonstration performance data.

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. Comply with Section 11000 – Equipment General Provisions.

1.08 WARRANTY

- A. Warranty requirements shall be as specified in Section 01600 – Materials and Equipment. Warranty requirements are supplementary to the individual equipment specifications.
- B. Comply with the Equipment Warranties requirements specified in Section 11000 – Equipment General Provisions.

1.09 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS:

- A. When operating at the maximum output speed each pump shall have a characteristic performance curve which meets the conditions listed in the pump schedule. The pumps and drive motors shall be capable of operating satisfactorily under the full-range of speed, flow and pressure conditions as defined by the pump schedule. Pump efficiency as defined herein shall include all mechanical losses from bearings and shaft seals.
- B. The impeller diameter required for the specified operating conditions shall not exceed 95% of the maximum impeller diameter of the pump provided to allow increased duty for future conditions.
- C. Each pumping unit and its driving equipment shall be designed and constructed to withstand the maximum turbine run-away speed of the unit due to backflow, including but not limited to back spinning from a dead stop and/or via a flow reversal condition that occurs immediately subsequent to a forward flow condition, through the pump with the primary TDH specified available at the pump discharge flange. Maximum reverse run-away speed shall not exceed 130 percent of the design operating speed.
- D. Pump manufacture shall certify a Minimum Continuous Stable Flow (MCSF) rating at maximum speed that is lower than the specified minimum operating flow. Where a reduced speed operating condition is specified, the manufacturer shall also certify MCSF at the pump speed required to meet this condition.
- E. Factory test acceptance grade for rating point shall be as specified herein, except where superseded via specification and/or scheduled values in the individual pump specifications, however power required shall not exceed the rated motor horsepower.
- F. Pump Operating Conditions: Refer to respective individual pump specifications for specific performance requirements.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Performance Curves: All centrifugal pumps shall have a continuously rising curve. In no case shall the required horsepower at any point on the performance curve exceed the rated horsepower of the motor or drive. Safety factors will not be considered in determining compliance with this requirement.

- B. Suction and discharge flanges shall conform to ASME B16.1 or B16.5 dimensions.
- C. For pumps in raw sewage service and as required by individual pump specifications, handholes shall be provided on the pump suction nozzle and the pump volute and shall be shaped to follow the contours of the casing or adjoining piping to avoid any obstructions in the water passage.
- D. The minimum ABMA L10 bearing life for all pump, motor and drive bearings shall be 60,000 hours unless otherwise specified in the individual pump specification sections.

2.02 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 - 1. Specification Section 05050 – Metal Fastening.
 - 2. Specification Section 11000 – Equipment General Provisions.
 - 3. Comply with individual pump specifications.

2.03 DEFAULT MATERIALS

- A. Pumps shall be constructed out of the materials specified in respective individual pumping specification sections. Material not specifically called for shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements unless otherwise specified in individual pumping equipment Specifications:

Component	Materials of Construction
Casings and Bowls	Close-grained gray cast iron, conforming to ASTM A 48, or equal
Impellers	ASTM B 148, aluminum bronze
Shafts, wetted	Type 400 series stainless steel
Shafts, non-wetted	AISI 4140 steel
Miscellaneous stainless steel parts	Type 316 series stainless steel
Anchor Bolts and Fasteners	Type 316 stainless steel

2.04 COMPONENTS:

- A. Refer to individual specification sections for specific requirements.
- B. Pump Shaft:
 - 1. The shaft shall be heat treated, turned, ground, and polished over its entire length and shall be provided with keyways on both ends.
 - 2. The shaft shall be sufficiently large in diameter to safely transmit the maximum torque developed by the drive unit and provide a rigid support for the impeller to prevent excessive vibration.
- C. Bearings:
 - 1. Bearings shall be designed for continuous heavy duty loads and for both axial and radial thrust loads.
 - 2. The specified ABMA L-10 life for bearings shall be under worst possible operating conditions.
 - 3. Bearings shall support the shaft and the complete rotating elements.
- D. Wear Rings:
 - 1. Wear rings shall meet or exceed the requirements of API 610, including but not limited to the following features:
 - a. Brinell hardness and Brinell hardness difference between adjacent wear parts.
 - b. Wear ring clearances
 - 2. Adjacent wear ring material combinations shall be non-galling.

2.05 STRUCTURAL STEEL

- A. Structural steel used for fabricating equipment supports, etc. shall conform to the requirements of Section 05500 – Metal Fabrications.
- B. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

2.06 DISSIMILAR METALS

- A. All dissimilar metals shall be isolated in accordance with Section 05010 – Metal Materials and to the satisfaction of the Engineer.

2.07 STANDARDIZATION OF GREASE FITTINGS

- A. Grease Fittings: Comply with Section 11000 – Equipment General Provisions.

2.08 APPURTENANCES

A. Seals:

1. Mechanical seals shall be furnished as specified in individual pumping equipment sections.
2. If the pump manufacturer recommends a better seal or alternate flushing arrangement for a specific application, it may be submitted to the Engineer for approval in accordance with the requirements of Section 01600 – Materials and Equipment.

B. Pressure Gauges:

1. Contractor shall supply all pressure gauges for all pumps by one manufacturer.
2. Gauges shall be provided through the instrumentation subcontractor to match other gauges on the project.
3. All gauges shall be provided with diaphragm seals or isolating ring seals as specified in Section 15114 – Miscellaneous Valves.
4. The Contractor shall furnish and install pressure gauges as shown on the Drawings, but the following gauges shall be provided as a minimum:
 - a. On the suction and discharge of each pump, except wet-pit submersible pumps and vertical turbine pumps.
 - b. On the discharge piping of each wet-pit submersible pump and vertical turbine pump in the locations shown on the Drawings or as directed by the Engineer.
 - c. Gauge ranges shall be coordinated with the pump manufacturer and shall meet the following requirements, except where otherwise specified:

Location	Type	Graduation	Suction Range	Discharge Range
Suction	Single Scale, Compound	FT H20	-34-FT	+34-FT
Discharge	Single Scale	FT H20	0-FT	Greatest of the following: - Shutoff + 5-FT - 120% of Maximum Pump Pressure

C. Shaft Couplings:

1. Except as otherwise specified in individual pump specification sections, flexible couplings for direct driven pumps shall be provided between the pump shaft and driver and keyed to pump and driver shafts. Flexible couplings shall be internal metal grid type couplings with a metal flange on both shafts with a metal cage in between, as manufactured by Falk, or equal.
2. Spacer couplings shall be provided where necessary to allow removal of the pump rotating element without disturbing the driver.
3. Comply with Section 11000 – Equipment General Provisions protective guard requirements.

D. Equipment Guards: Provide guards in accordance with OSHA requirements for all rotating assemblies that would otherwise be exposed at the operating deck level.

E. Provide access to:

1. Couplings
2. Oil drains

2.09 ELECTRICAL REQUIREMENTS

- A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 16 - Electrical specifications and the latest National Electric Code.
- B. All pumps shall be furnished with motors such that the motor shall not be overloaded throughout the full range of the pump operation. The use of service factor will not be allowed in determining overloaded condition.
- C. In the individual pump specifications, specified motor horsepower is intended to be the minimum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.
- D. Where variable frequency drives (VFDs) and/or variable speed drives (VSDs) are specified, the Contractor shall be responsible for coordinating between pump supplier and VFD/VSD supplier to ensure a complete and operational system. VFDs/VSDs shall be furnished under Division 16 - Electrical unless otherwise specified in the pump specification.

- E. Motor starters and controls shall be furnished and installed under Division 15 – Mechanical and Division 16 - Electrical unless otherwise specified in the individual pump specifications.

2.10 SPARE PARTS AND SPECIAL TOOLS

- A. Accessories, spare parts, and special tools shall be provided in accordance with Section 01600 – Materials and Equipment.
- B. Spare parts for equipment shall be furnished where indicated in the equipment Specifications and/or where recommended by the equipment manufacturer.
- C. Spare parts shall be identical and interchangeable with original parts.
- D. The Contractor shall furnish a one-year supply of all recommended lubricating oils and greases.
- E. Comply with Section 01600 – Materials and Equipment.

2.11 EQUIPMENT IDENTIFICATION

- A. Comply with the requirements of Section 11000 – Equipment General Provisions.
- B. All pumps shall be provided with a stainless steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with:
 - 1. the manufacturer's name
 - 2. year of manufacture
 - 3. model number
 - 4. serial number
 - 5. principal rating data including the following at the primary design point:
 - a. Capacity in gallons per minute
 - b. rated total dynamic head
 - c. speed in rotations per minute
 - d. efficiency at the primary design point.
- C. Each pump shall also be identified as to name and number by a suitable laminated plastic or stainless steel nameplate mechanically fastened with stainless steel hardware; for example, "Wastewater Pump – 1 (WWP-1)". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.

- D. Nameplates shall not be painted over.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. The terms Shop Testing and Factory Testing shall be considered to be interchangeable.
- B. Perform Shop Testing in conformance with Section 11000 – Equipment General Provisions.
- C. The Contractor shall be responsible for the coordination of factory testing of each pump, variable speed drive, and motor. Pump tests shall utilize the actual motors and pump motor bases and couplings to be furnished with the pumping equipment. Where required as indicated by the individual pump specification sections, variable speed pumps shall be tested with the actual variable speed controllers supplied for the project. Use of the pump manufacturers standard test motors and test stand is not acceptable.
- D. Manufacturer's factory performance tests and certified performance curves shall be provided for capacity power requirements and efficiency at specified minimum operating head, rated head, shut-off head and at as many other points as necessary. A copy of the certified pump curve shall be mounted on the inside of the control panel door. Two additional copies shall be provided to the Owner during start-up testing.
- E. Factory testing shall be conducted in accordance with the latest version of Hydraulic Institute Standard 14.6, Hydraulic Performance Acceptance Tests. For submersible pumps, testing shall be conducted in accordance with the latest version of ANSI/HI 11.6. For rotary pump tests, testing shall be conducted in accordance with the latest version of ANSI/HI 3.6 – Rotary Pump Tests.
- F. Hydraulic Performance Acceptance Tests
 - 1. The testing procedure shall be submitted to the Engineer for review and approval before scheduling the testing. The Owner/Engineer shall be given at least 2 weeks advanced notice of the scheduled testing date.
 - 2. Notification and payment of expenses for witness testing shall be as described in Section 11000 – Equipment General Provisions wherever individual pump specifications call for witness testing.
 - 3. Pump rating point shall be within the tolerances specified for Acceptance Grade 1U unless otherwise specified in the individual pump specifications.
 - 4. Factory performance test shall include a minimum of seven test points between shutoff and runout.

5. Where required by the individual equipment specification sections, NPSH (NPIP for rotary pumps) tests shall be conducted to demonstrate compliance with the specified NPSH (NPIP for rotary pumps) requirements. Where full curve NPSH testing is required, a minimum of four points shall be tested.
6. Certified test curves shall be provided for all centrifugal pumps unless otherwise specified in the individual pump specifications.
 - a. Certified tests will not be required for submersible sump pumps (as specified in Section 11130 – Submersible Non-Clog Pumps) with motors less than 5 hp.
 - b. Certified curves shall identify minimum continuous stable flow (minimum flow to avoid suction recirculation) and preferred operating region (POR) and allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.
7. Where required by the individual pump specification sections, factory vibration testing shall be performed to demonstrate compliance with HI 9.6.4.
8. For wet pit submersible pumps and vertical turbine pumps, all tests shall be run at minimum pump submergence specified in the individual pump specifications.
9. All instruments shall be calibrated as required by ANSI/HI 14.6, 11.6, or 3.6 as applicable.
- G. Where required in the individual pump specifications, a certified hydrostatic test shall be completed on each pumping unit in accordance with ANSI/HI 14.6 or 11.6 as applicable. Hydrostatic test pressure shall be 1.5 times maximum operating head or 1.25 times shutoff head, whichever is greater.
- H. Where required in the individual pump specifications, each individual casting shall be Brinell tested in a minimum of two places, in an area of representative casting thickness to ASTM Method E-10. Results shall be certified by a registered professional engineer.
- I. Shop testing of electric motors shall conform to:
 1. Section 11000 – Equipment General Provisions
 2. Section 16050 – Basic Electrical Materials and Methods
 3. Post-manufacture, pre-shipment motor impact test results (per HI 9.6.8, Appendix D) (for vertical pumps where a dynamic analysis is specified). Motor Reed critical frequency (RCF) mass and center of gravity properties shall be verified at the motor manufacturer's facility via motor impact testing. Before shipment of motor from motor factory, submit report of impact test results.
 4. The accuracy of post-manufacture, pre-shipment motor impact test RCF shall be within 10% +/- of the expected/proposed values obtained from the motor manufacturer during the motor proposal phase. If/where values are out of tolerance,

forced response analyses shall be repeated and adjustments to equipment made until a result that conforms with HI 9.6.8 and this specification is demonstrated via submitted data and accepted via the submittal process.

J. Shop testing of pumping trains - The right is reserved to require factory impact tests pre-shipment.

1. Post-manufacture, pre-shipment impact test results (per HI 9.6.8, Appendix D) (for pumps where a dynamic analysis is specified). Natural frequencies shall be verified at the manufacturer's facility via impact testing. Before shipment of equipment from the point of manufacturer, submit report of impact test results.
2. The accuracy of post-manufacture, pre-shipment impact test shall be within 10% +/- of the expected/proposed values obtained from the manufacturer during the proposal phase. If/where values are out of tolerance, forced response analyses shall be repeated and adjustments to equipment made until a result that conforms with HI 9.6.8 and this specification is demonstrated via submitted data and accepted via the submittal process.

3.02 SHIPMENT, DELIVERY, HANDLING, AND STORAGE

- A. Shipment, delivery and handling of equipment and materials shall be in accordance with Section 01600 – Materials and Equipment.
- B. Storage of equipment shall be in accordance with Section 01600 – Materials and Equipment.
- C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.
- D. Machined surfaces of all exposed pump openings or other exposed unpainted surfaces shall be protected by wooden blanks or Cosmoline, as appropriate, strongly built and securely bolted thereto.
- E. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment, and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Manufacturer's field services shall be in accordance with:
 1. Section 01650 - Checkout and Startup Procedures
 2. Section 11000 - Equipment General Provisions
 3. Section 01730 – Operations and Maintenance Data

- B. Unless otherwise referenced in the individual pump specification section, as a minimum the services of the manufacturer's representative shall be provided for as stated in the following schedule:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	2
Startup	1	2
Services after Startup	1	1

- C. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.04 INSTALLATION

- A. Pumping equipment shall be installed in accordance with Section 11000 – Equipment General Provisions, the manufacturer's recommendations, accepted procedures submitted with the shop drawings and as indicated on the Drawings, unless otherwise accepted by the Engineer.
- B. Level pump and motor and grout feet or baseplate with grout in accordance with Section 03600 – Grout and in accordance with Section 11000 – Equipment General. Ensure minimum grout depth is obtained as recommended by the pump and grout manufacturers.
- C. Drains: All gland seals, air valves, and drains shall be piped to the nearest floor drain or trench drain with stainless steel pipe or copper tube (as appropriate for the environment), properly supported with brackets.
- D. Contractor shall have unit responsibility for the proper coordination, sizing, and installation of the pump foundation/mounting requirements based on the manufacturer's recommendations, subject to Engineer's review and comment.

3.05 ALIGNMENT

- A. Pumping equipment shall be aligned in accordance with Section 11000 – Equipment General Provisions, the manufacturer's recommendations, accepted procedures submitted with the shop drawings and as indicated on the Drawings.
- B. Equipment shall be aligned and free from binding, scraping, excessive vibration, shaft runout, or other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing.
- C. As a minimum, comply with International Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.

3.06 FIELD TESTING

- A. Comply with Section 11000 – Equipment General Provisions for applicable preliminary and final field testing requirements supplementary to those described in this specification.
- B. Comply with Section 01650 – Checkout and Startup Procedures.
- C. All pumping units shall be field tested after installation, in accordance with the Contract Documents, to demonstrate satisfactory operation over the full operating speed range, without excessive noise, vibration, cavitation, and overheating of the bearings. The field testing shall be performed in the presence of an experienced field representative of the manufacturer of each major item of equipment, who shall supervise the following tasks and shall certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation:
 - 1. Pumps shall be tested for vibration over the full specified speed range. Unless otherwise required by individual specification sections, vibration shall be within the limits identified in the latest version of ANSI/HI 9.6.4 (or ANSI/HI 11.6 for submersible pumps), or manufacturer's limits if more stringent. If vibration is greater than 80% of the limits identified in ANSI/HI 9.6.4, follow-up vibration testing shall be completed after a 90-day break-in period to ensure that vibration remains within ANSI/HI 9.6.4 allowable limits. If vibration exceeds the allowable limits during the follow up testing, modifications shall be made as a warranty repair.
 - 2. Bearing temperatures shall be determined. A running time of at least 20 minutes shall be maintained for this test, unless liquid volume available is insufficient for a complete test.
 - 3. Pump performance shall be documented by obtaining concurrent readings, showing motor voltage, amperage, motor power, flow, pump suction head, and pump discharge head, for at least five (5) pumping conditions at full speed. One of the points shall be within -5% and 0%, and one being within 0% and +5% of the guarantee point flow rate; the remaining three points shall be spaced over the allowable operating range of the pump performance curve with points taken at or near the maximum allowable (shutoff) head region and at or near the maximum allowable flow (runout). Additional reduced speed testing shall be performed to demonstrate that pumps can achieve performance at turndown conditions where specified in individual pump specification sections. Each power lead to the motor shall be checked for proper current balance. Flow shall be measured to the extent possible by permanently installed instrumentation or drawdown measurement. The rated motor nameplate current shall not be exceeded at any point. Pumps with drive motors rated at less than five horsepower shall only be tested for overcurrent when overheating or other malfunction becomes evident in general testing. Field performance testing shall meet HI 14.6 pump acceptance test grade tolerance band grade 3B for all required test points.

- D. The field testing shall be witnessed by the Owner or its representative. The Contractor shall submit to the Engineer a written notification of all pump field tests a minimum of one (1) week prior to testing. In the event of failure of any pump to meet any of the above requirements, the Contractor shall make all necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the pump shall be re-tested at no additional compensation, until found satisfactory. The Contractor shall then certify in writing that the equipment has been satisfactorily tested, and that all final adjustments thereto have been made. Certification shall include date of final acceptance test, as well as a listing of all persons present during tests, and resulting test data. The costs of all Work performed in this Paragraph by factory-trained representatives shall be borne by the Contractor.

3.07 FAILURE OF EQUIPMENT TO PERFORM

- A. Comply with Section 11000 – Equipment General Provisions.

3.08 PAINTING

- A. Comply with Section 11000 – Equipment General Provisions.
- B. Comply with Section 09900 – Painting.

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SECTION 11350

SUBMERSIBLE SOLIDS-HANDLING PUMPS (DRY PIT)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place into satisfactory operation submersible (Dry Pit) solids-handling pumps at the locations shown on the Drawings and as specified herein. All pumps specified herein shall be supplied by the same manufacturer.
- B. Equipment shall be provided in accordance with the requirements of Section 11100 – Pumps General.
- C. The pump and all related equipment shall be designed for the wastewater applications specified herein and shall be suitable for continuous operation. The pump shall be bottom suction, side discharge construction and shall be supplied with a base plate. Pump base plate shall be installed on concrete pedestal matched to the pumps being supplied.
- D. Orientation of pump installation: Vertical

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Comply with Section 11100 – Pumps General

1.03 ACTION/INFORMATIONAL SUBMITTALS

- A. Product Data: Comply with Section 01300 – Submittals.
- B. Provide submittals identified in Section 11000 – Equipment, General Provisions in addition to the submittals identified herein and in addition to the submittals identified in other referenced specification sections.
- C. Provide submittals identified in Section 11100 – Pumps General.
- D. Dynamic Analysis Results Report

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
 - 1. Section 01300 – Submittals
 - 2. Section 01600 – Materials and Equipment
- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01300 – Submittals and Section 01730 – Operation and Maintenance Data.

C. Comply with Section 11100 – Pumps General.

1.05 MAINTENANCE MATERIALS SUBMITTALS

A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:

1. Section 01300 – Submittals
2. Section 01730 Operation and Maintenance Data

B. Comply with Section 01600 – Materials and Equipment.

C. Comply with Section 11000 – Equipment, General Provisions.

D. Comply with Section 11100 – Pumps General.

1.06 QUALITY ASSURANCE SUBMITTALS

A. Comply with Section 11100 – Pumps General.

B. Comply with Section 01650 – Check Out and Start Up Procedures.

1.07 GENERAL INFORMATION AND DESCRIPTION

A. Comply with Section 11000 – Equipment – General Provisions.

1.08 DYNAMIC ANALYSIS

A. Dynamic analyses shall be performed to determine the potential for a critical natural frequency (lateral, torsional, or structural) occurring within the normal operating speed range of the pumps. All dynamic analyses shall be performed in accordance with the latest edition of ANSI/HI 9.6.8 – Rotodynamic Pumps Guideline for Dynamics of Pumping Machinery and as specified in Section 11100 – Pumps-General.

B. Level of analysis required, minimum frequency separation margin, and other parameters of the analyses shall be as follows:

Schedule 11350 - 01

	EQ. PS
Lateral Analysis	
Level of Analysis	N/A
Separation Margin	20%
Torsional Analysis	
Level of Analysis	N/A

	EQ. PS
Separation Margin	20%
Structural Analysis	
Level of Analysis	Level 1
Separation Margin	20%
Include Suction Plug Valve	Yes
Include Concrete Base/Pedestal in FEA Model (Level 2 analysis only)	No

1.09 WARRANTY

- A. Warranty requirements shall be as specified in Section 01600 – Materials and Equipment. Warranty requirements are supplementary to the individual equipment specifications.
- B. Comply with the Equipment Warranties requirements specified in Section 11000 – Equipment, General Provisions.

1.10 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

Submersible Pump Performance Criteria Schedule – 11350 - 02

	EQ. PS
Number of Units	5
Pump Identification Numbers	Pump 1 Pump 2 Pump 3 Pump 4 Pump 5
Pump Shutoff Head (Allowable Range) (ft)	90-105
Rating Point (at Full Speed)	
Flow (gpm)	9,000
Total Head (ft)	55
Minimum Pump Efficiency (%)	70
NPSH Required shall not exceed (ft)	25
Rating Point shall be within the following range as percent of flow rate at BEP	85% to 110%
Maximum Flow Operating Point (at Full Speed)	
Flow (gpm)	11,000

	EQ. PS
Total Head Range (ft)	30 to 45
Minimum Pump Efficiency (%)	65
NPSH Required shall not exceed (ft)	35
Operating Point shall be within (AOR/POR)	AOR
Minimum Flow Operating Point (at Full Speed)	
Flow (gpm)	4000
Total Head Range (ft)	75 to 85
NPSH Required shall not exceed (ft)	18
Operating Point shall be within (AOR/POR)	AOR
Maximum Brake Horsepower for all operating points	200
Maximum Pump Operating Speed (rpm)	900
Fluid Pumped	Municipal Wastewater
Fluid Temperature (degrees F)	Ambient
Fluid Specific Gravity	0.9 to 1.2
Fluid pH range	6 to 9
Fluid Viscosity (absolute centipoise at 60-deg F)	1.08 E-5 ft ² /s
Minimum Solids Passing Size (in)	2
Suction Diameter (in)	20
Discharge Diameter (in)	16
Discharge Configuration	Centerline
Drive configuration	Close Coupled
Direction of rotation when viewed from driven end	CW
Minimum ABMA L-10 Bearing life [along the full length of the published operating curve] [within POR] (hours)	100,000
Factory test acceptance grade	1U
Rated Starts Per Hour, Minimum	10
Area Classification	Class 1, Div 1, Group D

- A. Fluid pumped is as scheduled and includes raw unscreened sewage and includes rags, grits, plastics etc.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Comply with Section 11100 – Pumps General, except where superseded in this specification section.
- B. Pump Type: Non-clog, dry pit submersible, centrifugal pump.

2.02 ACCEPTABLE MANUFACTURERS

- A. Pump Manufacturer:
 - 1. Xylem/Flygt
 - 2. No equal
- B. All equipment for the pumps, including motors and bases, shall be provided as a complete unit by the pump manufacturer.

2.03 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 - 1. Section 05050 – Metal Fastening
 - 2. Section 11000 – Equipment General Provisions
 - 3. Comply with individual pump specifications.
- B. Comply with Section 11100 – Pumps General

2.04 MATERIALS OF CONSTRUCTION

Materials of Construction Schedule – 11350- 03

Component	
	EQ. PS
Casing	Cast Iron, ASTM A48, CL35B
Suction Cover	Cast Iron, ASTM A48, CL35B
Seal Chamber	Cast Iron, ASTM A48, CL35B
Bearing Housing	Cast Iron, ASTM A48, CL35B
Shaft	ASTM A479 S43100-T, or AISI 420 SS 1.4021
Impeller	ASTM A-532 (Alloy III A) 25% chrome, or ASTM A48, Class 35B Grey Cast Iron

Component	
	EQ. PS
Wear Plate (If Applicable)	ASTM A48, Class 35B Grey Cast Iron
Fasteners	AISI Type 316L SS
O-Rings	Nitrile (Buna-N) or Viton
Control Panel	316 SS
Control Panel Rating	NEMA 4X
Base	Cast-in-Place Concrete
Base Plate	cast iron

2.05 COMPONENTS

A. Impeller

1. Impeller Type: One-piece, single-suction, semi-open, non-clogging, multi-vane, solids-handling, mixed flow type.
2. Impeller Construction:
 - a. Solids Passage:
 - 1) Shall be designed with smooth flow passages to pass a spherical solid of the specified size and to prevent clogging by stringy materials, self-cleaning.
 - 2) Impeller shall handle solids of the specified sphere size, fibrous materials, heavy sludge, and other matter found in normal wastewater applications.
 - b. The impeller shall be bolted, keyed and locked to the pump shaft at the factory. Adhesive or friction type fits are not acceptable.
 - c. Impeller shall be coated with the same system applied to the interior of the casing.
 - d. Impeller Balancing: Dynamically balanced.
3. Handling of Debris:
 - a. Impeller and insert ring with relief groove shall work together for self-cleaning operation.

- b. The pump must have demonstrated the ability to self-clean and pump wastewater containing solids such as plastics, heavy rags, grease and hair balls, wood paper products and stringy materials without plugging, both in tests and field applications.
- c. Pumps with fabricated cutter bars or casing shall not be accepted. Add-on cutting mechanisms below the pump inlet shall not be accepted.

B. Casing/Volute

- 1. Casing/Volute Type:
 - a. Bottom suction, side discharge construction.
- 2. Casing/Volute Construction:
 - a. The volute shall be single piece, non-concentric design.
 - b. Shall be designed with a pullout assembly so that the impeller can be withdrawn.
 - c. Casing shall be equipped with a clean-out port and cover which can be removed for access to the impeller.
 - d. All non-stainless steel metal surfaces coming in contact with the pumped media shall be protected by a factory applied spray coating.
- 3. Mounting:
 - a. Pump shall be mounted to a base plate.
 - b. Base plate shall be matched with equipment and equipment base(s).
 - c. Base plate shall be secured to concrete pedestal.
- 4. Solids Passage:
 - a. Passages shall have smooth unobstructed passages for solids. Volute shall have smooth fluid passages large enough at all points to pass any size solids which can pass through the impeller.
 - b. Passage Size: Large enough to pass a spherical solid of the specified size.
 - c. Flanges: Integrally cast ANSI Standard flat faced flange with 125-lb drilling,
- 5. Lifting: Casing/Volute shall be provided with lifting bolts and eye lugs for installation and maintenance of the pumps.

C. Shaft

1. Diameter: Shall be sufficiently large in diameter to safely transmit the maximum torque developed by the drive unit and of such design as to provide a rigid support for the impeller and to prevent excessive vibration.
2. Construction: The shaft shall be heat treated, turned, ground, and polished over its entire length and shall be provided with keyways on both ends.

D. Bearing Housing & Bearings

1. Type: Permanently lubricated, radial and thrust bearing anti-friction ball or tapered roller.
2. ABMA L-10 Bearing Life (at all points along the usable portion of the pump curve at maximum pump speed): Comply with scheduled herein.
3. Quantity: Two (2) per pump.
4. Construction:
 - a. Bearing housing shall fully enclose the bearings to prevent entrance of contaminants and shall be designed to provide for axial adjustment of rotating assembly.
 - b. Bearing housing shall be designed with a machined self-centering fit with the housing.
 - c. Bearing Lubrication: Bearings shall be permanently lubricated.
 - d. Comply with Section 11100 – Equipment General Provisions.

E. Base:

1. Equipment Support: Combination pump and motor base.
2. Base shall be a pedestal cast integrally with, or especially fabricated for, the pump casing and sufficiently sized to ensure rigid support.
3. Materials of construction shall be as scheduled.

F. Sealing of Mating Surfaces:

1. All mating surfaces where watertight sealing is required shall be machined and fitted with O-rings.

2. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. This will result in controlled compression of the O-rings without the requirement of a specific torque limit.
3. Secondary sealing compounds, rectangular gaskets, elliptical O-rings, grease or other devices shall not be acceptable.

G. Lifting System:

1. All anchor bolts, lifting bolts, eye lugs and lifting cable, etc. necessary for complete installation and maintenance of the pump shall be constructed of Type 316 stainless steel and shall be adequately designed for its intended use.

H. Pump Cooling System:

1. Requirement:
 - a. The motor shall be provided with an integral motor cooling system. A stainless-steel cooling jacket shall encircle the stator housing, providing for dissipation of motor heat regardless of the type of pump installation. An impeller, integral to the cooling system and driven by the pump shaft, shall provide the necessary circulation of the cooling liquid through the jacket. The cooling liquid shall pass about the stator housing in the closed loop system in turbulent flow providing for superior heat transfer. The cooling system shall have one fill port and one drain port integral to the cooling jacket.
 - b. The cooling system shall provide for continuous and completely non-submerged pump operation in air having a temperature of up to 40°C (104°F), in accordance with NEMA standards. Restrictions limiting the ambient or liquid temperatures at levels less than 40°C are not acceptable. Fans, blowers, or auxiliary cooling systems that are mounted external to the pump motor are not acceptable.
2. Type: Closed loop Cooling System Glycol jacket cooled, integral, self-supplying cooling system capable of cooling the motor at the rated starts per hour without an external cooling source.
3. Configuration: The cooling feature(s) shall surround the stator housing.

I. Suction Elbow:

1. The pump manufacturer shall provide a suction elbow to connect the pump to the suction piping.
2. Suction Elbow shall be a long radius reducing elbow.

3. Suction elbow ratio of radius of bend of elbow to diameter of large end of elbow: 0.83, minimum.

2.06 STRUCTURAL STEEL

- A. Comply with Section 11100 – Pumps General.

2.07 DISSIMILAR METALS

- A. Comply with Section 11100– Pumps General.

2.08 APPURTENANCES

- A. Shaft Seals: Shaft sealing shall be accomplished by one of the following methods as identified in the schedule below.
 1. Mechanical seals shall run in an oil-filled chamber to provide constant lubrication. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. Seal lubricant shall be FDA Approved, nontoxic.
 2. The lower, primary seal unit, located between the pump and the lubricant chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings. The lower seal shall be independent of the impeller hub.
 3. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings.
 4. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal. The seal system shall not be damaged when run dry. No external source of seal cooling or lubrication water shall be required.
 5. The following seal types shall not be considered acceptable nor equal to the dual independent seal specified: shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces. Cartridge type systems will not be acceptable. No system requiring a pressure differential to offset pressure and to effect sealing shall be used.

B. Shaft Seal Schedule

Shaft Seal Schedule – 11350 - 04

	EQ. PS
Shaft Sealing Arrangement	dual Mechanical Seal
Throat Bushing	No
Seal Flush Source / API Flush Plan	None
Lower Seal Unit – Seal Face Material	Tungsten carbide/Tungsten carbide, or Silicon Carbide/Silicon Carbide
Upper Seal Unit - Seal Face Material	Tungsten carbide/Tungsten carbide, or Silicon Carbide/Silicon Carbide
Metallic Components	316 SST
Flexible Components	BUNA N

- C. Pressure Gages: Provide pressure gages as indicated on the drawings and as specified under Section 11100 – Pumps General.
- D. Gauge taps shall be provided on the suction elbow and the discharge of the vertical submersible pumps in a location as directed by the Engineer. Gauge taps shall be threaded corporation stops, conforming to the requirements of Section 15000 – Basic Mechanical Requirements. Gauges shall be as specified in Division 16.
- E. All anchor bolts, lifting bolts, eye lugs, etc. necessary for complete installation and maintenance of the pump shall be furnished by Supplier and constructed of Type 316 stainless steel and shall be adequately designed for its intended use.

2.09 ELECTRICAL AND CONTROL REQUIREMENTS

- A. Comply with Specification Section 11100 – Pumps General, Section 16150 – Motors.
- B. All electrical appurtenances furnished by the equipment manufacturer shall be rated for installation in Class I, Division 1, Group D, hazardous location.
- C. Electrical and Instrumentation Requirements and Pump and Motor Monitoring and Protection Instrumentation:

Schedule – 11350 - 05

Service	EQ. PS
Motors	
Type	Close Coupled, fully enclosed submersible (Integrally mounted)

Service	EQ. PS
Motors	
Rating	460V, 3 ph, 60 Hz
Horsepower, Maximum	200
No. of Motor Poles	6-8
Speed, rpm (Nominal)	900 to 1200
Enclosure	Submersible, Explosion Proof
Insulation	Class H
Inverter Duty	Yes
Service Factor	1.15
Bearing Thermal Protection	Temperature Switches
Motor Speed Control	VFD
Maximum Sound at 3 feet, dBA	80
Space Heater	No
Motor Winding Temperature Protection	Temperature Switches
Separate Cooling Fan	No
Motor Differential Current Transformers / Six-Lead External Wye Connection	No
Motor Bearing RTDs	No
Motor Bearing Vibration	No
Pump Instrumentation	
Pump Bearing RTDs	No
Pump Bearing Vibration	No
Oil Reservoir Moisture Sensor	Yes
Packaged Control Panel	No
Packaged Control Panel Starter Size, minimum	No
Starter Type	VFD
Cooling Jacket	Yes, closed loop
Rated Starts Per Hour, Minimum	10

1. Oil Reservoir Moisture Sensor: Where an oil reservoir moisture sensor is required by this specification, moisture detector probes shall be provided in the oil-seal chamber. The pump manufacturer shall provide a moisture detection relay compatible with the probes.
2. Motor Protection Relay:
 - a. Each new pump shall be supplied with a manufacturer's motor protection alarm system, Flygt MAS 801/811 Pump Sensor Monitor, including a PEM module mounted on the pump itself and remote mounted control units (CU) and base units (BU) for interface with the pump VFDs and MCP PLC.
 - b. Pump manufacturer shall provide a NEMA1 enclosure for the MAS801/811 CU and BU components (two panels, each with a CU and three BU's for pumps 1, 2, and 3 and the other with two BU's for pumps 4 and 5). Enclosures shall accept 120V input and have its own 120/24Vdc transformer power to the MAS801/811 modules. Enclosure shall also provide terminals for a GO signal to the VFD (all conditions are good, and pump is enabled to run) and accept a reset signal for the motor temperature alarm. Pumps shall be explosion proof in order to accommodate the pump mounted PEM module that is mounted inside the pump casing.
 - c. The MAS801/811 system shall provide signals for motor stator temperature, pump bearing temperature, and pump vibration along with an alarm signal for moisture leak detection in the pump electronics section. These shall be sent to the MCP PLC for remote monitoring and alarm. The GO signal shall interface with VFD to stop the pump on either high temperature and high vibration. Moisture seal fail will be alarm only. Indication on the front of the drive shall be provided to indicate loss of GO signal.
 - d. Pump supplier shall submit wiring diagrams to show required wiring for interconnection of the sensor cable leads, CU/BU panels, power connections, and alarm output terminals.

D. Submersible Motors:

1. Motors shall conform to all applicable parts of Section 16150 – Motors. The pump motor shall be designed for operation with the voltage, frequency and phase electrical characteristics scheduled herein. See schedule for motor horsepower. Motors shall be mounted on each pump and shall conform to the latest applicable NEMA, IEEE, and ANSI standards for submersible service. The motors shall be rated for continuous duty with a minimum service factor as required by schedules herein.
 - a. Type: Squirrel-cage induction, housed in a watertight chamber.
 - b. The stator winding and stator leads shall be moisture resistant.

- c. Motor Insulation: Motor insulation shall be as scheduled herein.
 - d. The use of bolts, pins, or other fastening devices requiring penetration of the stator housing shall not be allowed.
 - e. Starts Per Hour: The motor shall be guaranteed for continuous unsubmerged duty, capable of sustaining a minimum scheduled starts per hour without overheating.
 - f. Motor Bearings: The motor shall be provided with pre lubricated radial and thrust bearings which are designed to carry the entire load which may be imposed upon it under all operating conditions.
 - g. All motors shall be housed in enclosures specifically designed for submersible pump application.
2. Cable Entry Water Seal:
- a. The cable entry water seal design shall insure a watertight and submersible seal without specific torque requirements.
 - b. The cable entry shall be comprised of a single cylindrical elastomer grommet, flanked by stainless steel washers all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The assembly shall bear against a shoulder in the pump top. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate gaining access through the pump top. The junction chamber containing the terminal board shall be sealed from the motor by an elastomer compression seal O-ring. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to the terminal board and thus perfectly leak proof. Each pump shall be equipped with separate terminal board that totally isolates the incoming power supply from the pump motor.
 - c. An acceptable alternate cable entry seal shall include cable leads shall enter at the top of the motor and shall allow the cable-to-motor connection to be accomplished in the field without soldering. All power and control lead wires shall be double sealed as they enter the motor in such a manner that cable-wicking will not occur. This sealing system shall consist of a rubber grommet followed by epoxy that is high in adhesive qualities and has a low coefficient of expansion. Each conductor shall have a small section of insulation removed to establish a window area of bare wire and each wire shall be untwisted and surrounded by epoxy potting material. A cable strain relief mechanism shall be an integral part of the sealing system. The cable sealing system shall be capable of withstanding an external pressure test of 1,200 psi as well as a

cable assembly pull test as required by Underwriters Laboratories. Power and control leads shall be terminated on a sealed terminal board. The terminal board and its bronze lugs shall be O-ring sealed.

E. Pump Cords:

1. Cord Length:

- a. Power and control cables between the pumps and the control panel shall be provided by the pump manufacturer who shall be responsible for reviewing the drawings as necessary to determine the required cable length.
- b. All pumps for the same application shall be provided with the same length of cable.
- c. No splices shall be allowed unless specifically called for in the electrical drawings.

2. Pump Cord Materials: PVC or oil resistant chloroprene rubber jacketed type SPC cable suitable for submersible pump applications.

3. Sizing:

- a. In Accordance with NEC and ICEA standards.
- b. Cords shall meet with MSHA approval.

4. Stainless steel strain relief connectors shall be furnished for all cables.

2.10 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 11000 – Equipment General Provisions and shall include the following for each series of pumps.

Spare Parts Schedule – 11350 - 06

Component	EQ. PS
Lower wear plate (insert disk)	1
Set of motor and pump bearings	1
Complete mechanical shaft seal assembly (upper and lower)	1
Sets of gaskets and O ring seals	2

2.11 EQUIPMENT IDENTIFICATION

- A. Comply with Section 11100 – Pumps General.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. Factory testing shall be in accordance with Section 11100 – Pumps General, and shall include:

Shop Testing Schedule – 11350 - 07

	EQ. PS
Hydraulic Performance Testing	Yes
Witnessed Performance Testing	No
Certified Performance Curves	Yes
Vibration Testing	Yes
Mechanical Test	Yes
String Test	No
NPSH Test	No
Hydrostatic Test	Yes
Casing Hardness Test	No

1. Impeller, motor rating and electrical connections shall be checked.
2. Shop testing shall be in accordance with current applicable Hydraulic Institute Standards.

3.02 SHIPMENT, DELIVERY, HANDLING, AND STORAGE

- A. Shipment, delivery and handling of equipment and materials shall be in accordance with Section 01600 – Materials and Equipment.
- B. Storage of equipment shall be in accordance with Section 01600 Materials and Equipment.

3.03 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11100 – Pumps General. For each series of pumps, field services shall include the following site visits:

Site Visits Schedule 11350 - 08

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

3.04 INSTALLATION

- A. Install pump in strict accordance with manufacturer's recommendations and Section 11100 – Pumps General.

3.05 ALIGNMENT (NOT USED)

3.06 FIELD TESTING

- A. Field testing shall be in accordance with Section 11100 – Pumps General, and shall include:

Field Testing Schedule 11350 - 09

	EQ. PS
Field Performance Testing	Yes
Vibration Testing	Yes
Natural Frequency "Bump" (Impact) Test	No

3.07 FAILURE OF EQUIPMENT TO PERFORM

- A. Comply with Section 11000 – Equipment General Provisions.

3.08 PAINTING

- A. Comply with Section 11000 – Equipment General Provisions.
- B. Comply with Section 09900 – Painting.

- END OF SECTION -

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Section 16010

ELECTRICAL – GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SCOPE

- A. Furnish all labor, materials, equipment and incidentals required for a complete electrical system hereinafter specified and shown on the Contract Drawings.
- B. The work, apparatus and materials which shall be furnished under these Specifications and accompanying Contract Drawings shall include all items listed hereinafter and/or shown on the Contract Drawings. Certain equipment will be furnished as specified in other sections of these Specifications which will require wiring thereto and/or complete installation as indicated. All materials necessary for the complete installation shall be furnished and installed by the Contractor to provide complete power, lighting, communication systems, field instrumentation wiring, and control systems as indicated on the Contract Drawings and/or as specified herein.
- C. The Contractor shall furnish and install the necessary cables, transformers, protective devices, conductors, exterior electrical system, etc., to serve motor loads, lighting loads and miscellaneous electrical loads as indicated on the Contract Drawings and/or as specified hereinafter.
- D. All electronics, as part of electrical equipment, shall meet the atmospheric conditions of the space the equipment is installed in. All electronics that are not installed in a conditioned environment shall be fungus resistant.
- E. All electrical equipment shall be rated for the conditions of the physical installation. All electrical rooms are designated as corrosive areas and the appropriate raceway, equipment and appurtenances shall be installed. All indoor chemical and process equipment areas shall be considered wet locations.
- F. The work shall include testing of all equipment and wiring at the completion of the work and making any minor connection changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.
- G. Mount and wire instruments furnished under other Divisions of these Specifications.
- H. Make all field connections to instrument panels and other control panels furnished under other Divisions of these Specifications.
- I. For instrumentation, the Contractor shall furnish and install all conduit, wire and interconnections between primary elements, transmitters, local indicators and receivers.
- J. Furnish necessary devices and make connections to provide power to equipment. This will require appropriate receptacles in some cases and direct wiring in other cases, depending upon equipment furnished.

- K. Install and wire all thermostats and other devices furnished under other Divisions of this Specification.
- L. All planned power interruptions shall be at the City's convenience. Each interruption shall have prior approval.
- M. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work, which may be reasonably implied as being incidental to the work of this Section, shall be furnished at no extra cost.
- N. Where the City's drawings "Low Voltage (LV) Standards" for facility projects and "Lift Stations (LS) Standards for Lift Stations" is referenced in these Division 16 specifications, refer to the electrical and instrumentation drawings for these requirements. Should there be any conflicts, the more stringent requirement shall apply.

1.2 INSPECTION OF THE SITE AND EXISTING CONDITIONS

- A. The Electrical Drawings were developed from past record drawings and information supplied by the City. The Contractor shall verify all scaled dimensions prior to submitting bids.
- B. Each Bidder or his authorized representative shall, before preparing his proposal, visit all areas of the facilities and structures in which work under this division is to be performed and inspect carefully the present installation. The submission of the proposal by this Bidder shall be considered evidence that he or his representative has visited the area and noted the locations and conditions under which the work will be performed and that he takes full responsibility for a complete knowledge of all factors governing his work. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.
- 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 City. Do such work when directed by the Engineer.
- D. Contractor shall protect all existing underground utilities during construction. The Contractor to pay for all required repairs without increase in Contract cost, should damage to underground utilities occur during construction.

1.3 CONTRACTOR QUALIFICATIONS

- A. The Contractor shall be experienced in this type of work; "experienced" means having successfully completed a minimum of the following:
 - 1. Seven (7) verifiable years in the performance of work on projects with similar skill set requirements including but not limited to Medium Voltage Distribution Apparatus and cable systems;
 - 2. Minimum of two (2) years of which have taken place within the past sixty (60) months;
 - 3. A minimum of five (5) projects similar in size and scope to this Project;

1.4 SERVICE AND METERING

- A. Permanent electrical service is provided by OUC.

1.5 COORDINATION

- A. The Contractor shall coordinate, in writing with complete written documentation, with the other trade contractors to deliver a seamless integrated coherent system.
- B. The Contractor shall coordinate with a minimum of a two-week notice, in writing with complete written documentation, with the City to minimize any interruption to existing production and schedules. All planned power interruptions, testing and training schedules shall be at the City's convenience and approved by City.

1.6 CODES, INSPECTION AND FEES

- A. All material and installation shall be in accordance with the latest edition of the National Electrical Code® (NEC®) and all applicable national, local and state codes.
- B. The Contractor shall pay all fees required for permits and inspections including any charges associated with the service modifications.

1.7 QUALITY CONTROL

- A. The basis of design is based on the Manufacturers listed in the specifications and the Contract Drawings. Acceptance of alternate Manufacturers shall be made at the Engineer's and City's discretion. Manufacturers seeking Engineer approval shall submit a complete qualifications package. The package shall be submitted a minimum of ten (10) days prior to the bid date for the Engineer's review and approval.
- B. Failure to submit a request for an alternate as per the Contract Documents shall deem the Manufacturer as "Not Equal" and will not be reviewed during the shop drawing submittal phase.
- C. The request for an alternate package shall include the following:
 - 1. A listing of experience in systems of similar size and complexity. Provide references for a minimum of five (5) completed water and/or wastewater projects furnished within the last four (4) years. For each identify the following:
 - a. Project name;
 - b. Project dollar value;
 - c. General Contractor, with contact name and telephone number;
 - d. Engineer of Record (EOR) with contact name and telephone number;
 - e. City, with contact name and telephone number;
 - 2. Submit evidence of UL Listed factory and/or facility;
 - 3. Have an established service facility from which qualified technical service personnel and parts may be dispatched upon call. Such a service facility shall be no more than six (6) hours travel time from the jobsite. Identify the location of said facility;
 - 4. A complete package including equipment data sheets, layout information, UL Listing and proposed accessories including but not limited to the 480-Volt switchgear, Motor Control Centers, Profibus Devices, control panels and communication devices.

5. A complete listing of any and all exceptions taken by the alternate Manufacturer to the contract documents with the proposed alternatives required to meet the intent of the specifications. Failure to submit proposed alternatives shall deem the package as non-compliant and therefore the alternate Manufacturer will be deemed "Not Equal".
- D. All equipment furnished by the Manufacturer shall be of the latest and most recent design and shall have overall accuracy as guaranteed by the Manufacturer.
- E. Materials and equipment used shall be UL Listed wherever such approved equipment and materials are available.
- F. Component equipment shall be as supplied by one of the Manufacturers named or approved equal. The design of the control system is based on the named Manufacturer's equipment used in the design, if there is a difference.
- G. To facilitate the City's operation and maintenance, products shall be of the same major Manufacturer, with panel mounted devices of the same type and model as far as possible.
- H. In order to insure the interchangeability of parts and the maintenance of quality, strict compliance with the above requirements shall be maintained.
- I. The Manufacturer shall designate a single point of contact for interface with the Engineer on this project. The Engineer reserves the sole right to approve or reject this point of contact.
- J. The Manufacturer shall provide experienced personnel on-site to coordinate and/or perform installation, termination, and adjustment; on-site testing; City training; and startup assistance for the electrical system.

1.8 TESTS

- A. Test all systems and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the City's personnel in the proper operation of the systems.
- B. The following minimum tests and checks shall be made prior to the energizing of electrical equipment and cabling. Testing shall be by an independent NETA certified testing firm, and a certified test report shall be submitted stating that the equipment meets and operates in accordance with the Manufacturer's and job specifications, and that equipment and installation conforms to all applicable Standards, Contract Drawings and Specifications:
 1. Testing and setting of protective relays for calibration and proper operation;
 2. Mechanical inspection of all 480-Volt circuit breakers 100-amps and larger to assure proper operation;
 3. Motors: Megger to ground each motor winding; Record date, motor temperature, terminal, reading and operator and have City representative sign off on each reading;
 4. 480-Volt Conductors: Megger to ground prior to termination all conductors not used for service conductors. Record the date, conductor, reading and operator and have City representative sign off

- on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
5. Service Conductors: Megger to ground prior to termination in the presence of the Engineer or his representative all 600-volt service conductors. Record date, conductor, reading, operator, and have the City representative sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
 6. 480-Volt Power Panelboards/Switchboards: After installing, with circuit breakers closed, but prior to terminating any conductors, megger each phase to phase and phase to ground. Record the date, test (i.e. A/B or A/G), reading and operator and have City's representative sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
 7. Connections & Terminations: Torque to Manufacturer's values in the presence of the Engineer or his representative. Record the date, conductor, torque, and operator and have the Engineer sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
 8. Hot Spot Testing: Perform infrared hot spot inspection of all 480-Volt and 13.2-kV terminations, and associated equipment as soon as determined by the Engineer that representative loads are present. Record the date, gear conditions found, operator and have the City's representative who must be present for the inspection sign off in each instance. Submit report in both hard copy and electronic format (PDF) for final approval.
 9. Miscellaneous:
 - a. Meggering must be done at 1000VDC for one-minute. The ground plane used must be the one established at the main source of energy for conductors. The motor frame may be used for the ground plane for motors.
 - b. In the course of construction, it will become necessary to temporarily energize some systems for testing. Confirm that any motor has been meggered prior to connection and testing. Do not leave any motor or system unattended and energized without written authorization.
 - c. An unsuccessful test will be one in which any one of the three megger readings differs from another by more than 25%. Engineer shall determine if cables and/or equipment bussing shall be replaced.

1.9 SLEEVES AND FORMS FOR OPENINGS

- A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

1.10 CUTTING AND PATCHING

- A. All cutting, and patching shall be done in a thoroughly workmanlike manner.

1.11 INTERPRETATION OF CONTRACT DRAWINGS

- A. The Contract Drawings are not intended to show exact locations of conduit runs.
- B. All three-phase circuits shall be run in separate conduits unless otherwise shown on the Contract Drawings.
- C. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.
- E. No shared or common neutrals shall be installed.
- F. The Contractor shall harmonize the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor without additional expense to the City. In case interference develops, the City's authorized representative is to decide which equipment, piping, etc., must be relocated, regardless which was installed first.
- G. Verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- H. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. Obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.
- I. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- J. Circuit layouts shown are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the equipment.
- K. The ratings of motors and other electrically operated devices together with the size shown for their branch circuit conductors and conduits are approximate only and are indicative of the probable power requirements insofar as they can determine in advance of the purchase of equipment.
- L. All connections to equipment shall be made as shown, specified, and directed and in accordance with the Manufacturer's approved shop drawings, regardless of the number of conductors shown on the Contract Drawings.

1.12 SIZE OF EQUIPMENT

- A. Investigate each space in the building where equipment must pass to reach its final location. If necessary, the Manufacturer shall be required to ship his material in sections, sized to permit passing through such restricted areas in the building.

- B. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably, to ensure that the tilting does not impair the functional integrity of the equipment.

1.13 RECORD DRAWINGS

- A. Requirements for record drawings are specified in Section 01050.

1.14 OPERATIONS AND MAINTENANCE (O&M) MANUALS

- A. Requirements for O&M manuals are specified in Section 01730. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc. to instruct operating and maintenance personnel unfamiliar with such equipment.
- B. All operations and maintenance data documents shall be provided in both hardcopy, bounded in separate three ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media (3.0 USB flash drive) shall be provided.
- C. All operations and maintenance drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media (3.0 USB flash drive) shall be provided.
- D. Manuals shall include the following as a minimum:
 - 1. A comprehensive index;
 - 2. A complete “as-built” set of approved shop drawings;
 - 3. A complete list of the equipment supplied, including Manufacturer, model and serial numbers, ranges and pertinent data;
 - 4. A table listing of the “as left” settings for all electric/electronic components (timing relays, alarm & trip settings);
 - 5. System schematic drawings “as-built”, illustrating all components, piping and electric connections of the system supplied under this Section.
 - 6. Detailed service, maintenance and operation instructions for each item supplied
 - 7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures;
 - 8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions;
 - 9. Complete parts list with Manufacturer stock numbers, including spare parts;

1.15 COMPONENT INTERCONNECTIONS

- A. Component equipment furnished under this Specification will not be furnished as integrated systems. Contractor shall field install and wire

completely all components.

- B. Contractor shall analyze all systems components and their shop drawings, identify all terminals and prepare drawings and wiring tables necessary for component interconnection. Contractor shall provide crimp on wire numbers on both ends of all control wiring installed between all panels furnished under this contract. These numbers shall directly relate to the interconnect wiring drawing furnished by the Contractor and be reflected in the record drawings submitted.

1.16 SHOP DRAWINGS

- A. Submit shop drawings in accordance with Specification Section 01420.
- B. As specified under other sections, shop drawings shall be submitted for approval of all materials, equipment, apparatus, and other items as required by the Engineer.
- C. The submittal shall be for the entire Specification Section. If any portion of the section is missing or incomplete, the submittal shall be rejected and resubmitted.
- D. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- E. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- F. Prior to submittal by the Contractor, all shop drawings shall be checked for accuracy and contract requirements. Shop drawings shall bear the date checked and shall be accompanied by a statement that the shop drawings have been examined for conformity to Specifications and Drawings. This statement shall also list all discrepancies with the Specifications and Drawings. Shop drawings not so checked and noted shall be returned.
- G. A copy of each specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with any request for information (RFI) clarifications and/or applicable responses, 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.
- H. Shop drawings shall be submitted for the following equipment:
 - 1. Conduit;

2. Wire and Cables;
 3. Circuit Breakers
 4. (LS) EYSR Fittings;
 5. Tagging Conventions of cables and wires;
 6. Conduit drawings, building and site layouts;
- I. The Manufacturer name and product designation and catalog data sheet shall be submitted for the following material:
1. Conduit;
 2. Receptacles;
 3. Boxes and fittings;
 4. Wiring Devices;
 5. Lamps;
- J. The Engineer's check shall be only for conformance with the design concept of the project and compliance with the Specifications and Contract Drawings. The responsibility of, or the necessity of, furnishing materials and workmanship required by the Specifications and Contract Drawings which may not be indicated on the shop drawings is included under the work of this Section.
- K. The responsibility for all dimensions to be confirmed and correlated at the job site and for coordination of this work with the work of all other trades is also included under the work of this Section.
- L. No material shall be ordered, or shop work started until the Engineer's approval of shop drawings has been given.

1.17 MATERIALS

- A. The materials used in all systems shall be new, unused and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or Manufacturer's specifications shall be submitted for approval as required by the Engineer.
- B. Materials and equipment used shall be Underwriters Laboratories (UL) Listed.
- C. Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry permanent shelters. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as directed by the Engineer, at the expense of the Contractor, or shall be replaced by the Contractor at his own expense.

1.18 DEMOLITION

- A. Remove all electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused. Remove all unused exposed conduit and wiring back to point of concealment. Remove unused wiring in concealed conduits back to source (or nearest point of usage). Electrical work to be removed corresponds to the associated mechanical equipment to be removed.

- B. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or shall be suitably relocated, and the system restored to normal operation. Coordinate outages in systems with the City. Where duration of proposed outage cannot be allowed by the City, provide temporary connections as required to maintain service.
- C. All removals and relocations of existing installations cannot be completely detailed on the Drawings. Contractor is responsible for determining the exact requirements for the project based upon site investigation.
- D. Continuous service is required on all circuits and outlets affected by these changes, except where the City will permit outage for a specific time. Obtain City's written consent before removing any circuit from continuous service.
- E. Where required disconnect and/or remove any part of an existing circuit, reconnect that circuit to reestablish service in the remaining portion.
- F. Remove exposed conduits, wire ways, outlet boxes, pull boxes and hangers made obsolete by the alternations, unless specifically designated to remain. Exposed conduits shall be removed back to point of concealment, where they shall be cut and threaded for a cap. A threaded cap shall then be installed. Conduits may be removed back to first coupling if within 3-inches of point of concealment. Cut back in traffic areas to the floor level and patch.

1.19 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT

- A. In general, it is intended that all materials and equipment indicated to be removed and disposed of by the Contractor shall, upon removal, become the Contractor's property and shall be disposed of off the site by the Contractor at their expense, unless otherwise directed by the City.
- B. Reuse of wire will not be permitted. An exception is the reuse or relocation when wire is part of an existing lighting branch circuit and reuse or relocation is specifically designated and can be accomplished without removing and re-pulling the wire.
- C. All electrical equipment to be salvaged shall be removed and moved by the Contractor to a location on the site for storage as directed by the City.

1.20 COORDINATION, SHORT CIRCUIT AND ARC FLASH HAZARD STUDY

- A. See Section 16015 - Electrical Systems Analysis for specifics.

1.21 CONDUIT DRAWINGS

- A. The Contractor shall submit complete conduit and equipment layout drawings. These ¼-inch = 12-inch scaled layout(s) of the new and existing electrical equipment in the electrical room or major electrical equipment in a mechanical room showing physical sizes of all equipment and their spatial relationships. Nonelectrical equipment shall be approved before finalizing the electrical layout. The drawing shall include the following:
 - 1. Conduit layouts shown on floor plans drawn at not less than ¼-inch = 12-inch scale. The layouts shall include locations of electrical equipment, transformers, panelboards, control panels and equipment, motors, switches, large junction or pull boxes, instruments, and any other electrical devices connected to concealed or buried conduits;

2. Plans shall be drawn on high quality reproducible, size 36-inch x 24-inch, and shall be presented in a neat, professional manner utilizing AutoCAD format. Contractor to submit both hard copies and an electronic copy for approval;
 3. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved;
- B. In addition to the manufacturer's equipment shop drawings, the Contractor shall submit for the approval, electrical working drawings for the overall site work containing the following:
1. Concealed and buried conduit layouts shown on plans drawn at not less than 1-inch = 30-foot-0-inch scale. The layouts shall include locations of cabling, transformers, manholes, conduit sleeves and any other electrical devices required;
 2. Plans shall be drawn on high quality reproducible, size 36-inch x 24-inch, and shall be presented in a neat, professional manner utilizing AutoCAD format. Contractor to submit both hard copies and an electronic copy (AutoCAD format) for approval;
 3. Ductbanks shall not be poured until conduit layouts are approved;
- C. Existing AutoCAD drawing files are available from the Engineer.

1.22 WARRANTY

- A. Provide a warranty for all the electrical equipment in accordance with the requirements of the other Division 16 Sections, but in no case less than one (1) year from the date of Substantial Completion.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

End of Section

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ELECTRICAL SYSTEMS ANALYSIS

PART 1 - GENERAL

1.1 SCOPE

- A. The requirements of this specification shall apply to the new electrical distribution system for the City. The end result shall be a fully protected and properly coordinated system with proper arc flash safety labels and personal protective equipment recommendations.
- B. The Contractor shall furnish a Short-Circuit Study and a Protective Device Coordination Study as described herein. The Protective Device Coordination Study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to, and including, the main breaker and feeder circuits in each panelboard. The study shall also include transformers, variable frequency drives, reduced-voltage starters, emergency and/or standby generators, distribution switchgear and protective devices.
- C. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E® - Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes supplements ANSI/IEEE C37.010b and C37.010d);
 - 2. ANSI 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. ANSI C37.10 - IEEE Guide for Diagnostics and Failure Investigation of Power Circuit Breakers;
 - 4. ANSI C37.13 – Low Voltage AC Power Circuit Breakers Used in Enclosures;
 - 5. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories;
 - 6. ANSI C57.12.00 - IEEE General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers;
 - 7. Institute of Electrical and Electronics Engineers (IEEE) 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems;

8. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings;
9. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems;
10. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis;
11. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems;
12. IEEE 1584 - Guide for Performing Arc Flash Hazard Calculations;
13. National Fire Protection Association® (NFPA) 70 – National Electric Code® (NEC®);
14. NEC® Article 409 – Industrial Control Panels;
15. NFPA® 70E® - Electrical Safety in the Workplace;
16. Occupational Safety & Health Administration (OSHA) 29-CFR, Part 1910, sub part S;
17. UL 508A - Industrial Control Panels;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
 1. The results of the Short-Circuit Study; Protective Device Coordination Study and Arc Flash Analysis shall be summarized in a preliminary and final summary report.
 2. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch (11-inch x 17-inch drawings and tables are permitted) and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
 3. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format shall be provided. Two sets of hardcopies and two sets of electronic media shall be provided.
 4. All Power Systems Design & Analysis “source” files in electronic format shall be provided to the City.
 5. The preliminary Short-Circuit Study and Protective Device Coordination Study shall be submitted within 30-days of Notice to Proceed and shall form the basis for approval of all other electrical equipment in the power distribution system.
 6. The Contractor is expected to review the results of the preliminary Short-Circuit Study and Protective Device Coordination Study 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.

7. The final Short Circuit Study and Protective Device Coordination Study shall incorporate all comments from the shop drawing submittals and include the Arc Flash Analysis.
8. The Contractor shall ensure proper, permanent adhesive non-fading and complete Arc Flash warning labels are applied to all appropriate electrical equipment installed under this contract when the final studies have been approved.

1.4 STUDY SCHEDULE

- A. The preliminary (initial), complete Short Circuit Study and Protective Device Coordination Study must be submitted and reviewed before Engineer will approve Shop Drawings for switchgear, unit sub stations, breakers, MCCs, switchboards, VFDs, 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 Study, the Protective Device Coordination Study and the Arc Flash Analysis shall be updated prior to Project Substantial Completion. The final studies shall utilize characteristics of as-installed equipment actual wire run lengths and materials.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Contractor shall furnish all field data (feeder cable sizes, approximate feeder length motor data, generator data, existing relay settings, etc.) as required for the power system studies. The Engineer performing the Short Circuit Study, the Protective Device Coordination Study and the Arc Flash Analysis shall furnish the Contractor with a listing of required data immediately after Contract Award. 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.
- 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 the Contract Documents provided by City 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 SYSTEMS ANALYSIS, INC. (SKM) Power*Tools for Windows®.
- 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.
 - I. Existing Equipment:
 - J. Provide a comprehensive document containing the Short Circuit Study, the Protective Device Coordination Study and the Arc Flash Analysis. As a minimum the report structure shall contain:
 - 1. Executive Summary;
 - 2. Methodology;
 - 3. One Line Diagram(s);
 - 4. Short Circuit Analysis;
 - 5. Short Circuit Analysis Results/Conclusions/Recommendations;
 - 6. Protective Device Coordination Analysis;
 - 7. Recommended protective devices settings;
 - 8. Arc Flash Analysis;
 - 9. Arc Flash PPE recommendations;
 - K. Acceptable Electrical Systems Analysis Software Manufacturers
SKM SYSTEMS ANALYSIS INC. www.skm.com
 - 1. Power*Tools for Windows®
 - 2. (Use latest version of PTW available at time of Contract Award)
 - 3. Power Systems Design & Analysis Suite of Modules;
 - 4. SKM DAPPER® Short Circuit Study;
 - 5. SKM CAPTOR Protective Device Coordination Study;
 - 6. SKM ARC FLASH Analysis;
 - 7. NO EQUAL

2.2 SHORT CIRCUIT STUDY

- A. General:
 - 1. Use cable impedances based on copper conductors. Use actual conductor impedances, if known. 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 77 °F (25 °C).
 - 4. Use 600-volt cable reactance's based on use of typical data of conductors to be used on this project.
 - 5. Use transformer impedances 92.5% 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 City in writing, of existing, circuit protective devices improperly rated for the calculated available fault current
- E. Through the 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 their coordination with meeting the requirements of UL 508A and NEC® Article 409.

2.3 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. Low voltage fuses including Manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - 4. Low voltage equipment circuit breaker trip devices, including Manufacturer's tolerance bands.
 - 5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
 - 6. Transformer damage curves.
 - 7. Conductor damage curves.
 - 8. ANSI transformer withstand parameters.
 - 9. Significant symmetrical and asymmetrical fault currents.
 - 10. Ground fault protective devices and settings (if applicable).
 - 11. Pertinent motor starting characteristics and motor damage points.
 - 12. Pertinent generator short circuit decrement curve and generator damage point.
 - 13. Circuit breaker panelboard main breakers, where appropriate.
 - 14. 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.

2.4 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. Where appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the Short Circuit and the Protective Device Coordination Studies;
- 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, busway and unit substations, variable frequency drives, and industrial control panels) where

- work could be performed on energized parts.
- D. The Arc Flash Hazard Analysis shall include all low voltage (600V and below) and significant locations in 240 volts and 208VAC systems fed from transformers equal to or greater than 125 kVA. Arc Flash Hazard Analysis on low voltage systems 120VAC and below is not required.
 - E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering incident energy of 1.2 cal/cm²;
 - F. The Arc Flash 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 (PPE), in accordance with OSHA standards, and proper complete 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 busway; grounding type; number of phases and connection; and working distance.

2.5 TABULATIONS

- A. Input Data:
 - 1. Utility three-phase and line-to-ground available contribution with associated X/R ratios;
 - 2. Short circuit reactance's 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;

2.6 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

3.1 GENERAL

- A. Adjust relay and protective device settings according to values established by coordination study.
- B. Make minor modifications to equipment as required accomplishing conformance with the Short Circuit Study and the Protective Device Coordination Study.
- C. Notify Engineer in writing of any required major equipment modifications.

End of Section

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ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

- A. Extent of electrical identification work is indicated by drawings and schedules, or items listed in this specification.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
- C. Types of electrical identification work specified in this section include the following:
 - 1. Electrical power, control and communication conductors;
 - 2. Operational instructions and warnings;
 - 3. Danger signs;
 - 4. Equipment/System Identification signs or tags;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) A13.1 - Scheme for the Identification of Piping Systems;
 - 2. ANSI Z53.1 - Color Designation;
 - 3. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 4. NEC® Article 110 – Requirements for Electrical Installations;
 - 5. NEC® Article 200 – Use and Identification of Grounded Conductors;
 - 6. NEC® Article 210 – Branch Circuits;
 - 7. NEC® Article 215 – Feeders;
 - 8. NEC® Article 230 – Services;
 - 9. NEC® Article 250 – Grounding and Bonding;
 - 10. NEC® Article 310 – Conductors for General Wiring;
 - 11. NEC® Article 400 – Flexible Cords and Cables;
 - 12. NEC® Article 408 – Switchboards and Panelboards;
 - 13. NEC® Article 504 – Intrinsically Safe Systems;
 - 14. NEC® Article 647 – Sensitive Electronic Equipment;
 - 15. NEC® Article 708 – Critical Operations Power Systems;
 - 16. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

17. NFPA® 70E® - Electrical Safety in the Workplace;
18. Underwriters Laboratories (UL) 969 - Marking and Labeling Systems;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Master drawing index;
 4. Dimensioned front & plan view of the assembly;
 5. Installation information;

1.4 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacturing of electrical identification products of types required, whose products have been satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing electrical identification work similar to that required for this project.
- C. NEC® Compliance: Comply with NEC® as applicable to installation of identifying labels and markers for wiring and equipment.
- D. UL Compliance: Comply with applicable requirements of UL 969 - Marking and Labeling Systems, pertaining to electrical identification systems.
- E. ANSI Compliance: Comply with applicable requirements of ANSI Standard A13.1 - Scheme for the Identification of Piping Systems, and ANSI Standard Z53.1 - Color Designation.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION MATERIALS

- A. Except as otherwise indicated, Contractor shall provide Manufacturer's standard products of categories and types required for each application. Where more than a single type is specified for an application, the selection Contractor's option, but provide single selection for each application.

B. Conduit System Markers:

1. Plastic Markers: Provide Manufacturer's standard pre-printed, flexible or semi rigid, permanent, conduit markers, extending 360° around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretension snap-on.
2. Voltage Marking: Except as otherwise indicated, provide lettering that indicates voltage of the conductor(s) in conduit.
 - a. Provide 4-inch minimum length with 7/8-inch minimum lettering for 2-inch and smaller conduit.



- b. Provide 8-inch minimum length with 1-7/8-inch minimum lettering for larger than 2-inch conduit.



3. Painted Band: Provide painted band in color to match plastic markers or tape.

C. Cable/Conductor Identification Bands:

1. Provide Manufacturer's standard aluminum wrap-around cable/conductor markers, of size required for proper application, and numbered to show circuit identification.
2. Provide Manufacturer's standard vinyl cloth self-adhesive cable/conductor markers of the wrap-around type; either pre-numbered plastic-coated type or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

D. Plasticized Tags:

1. Provide Manufacturer's standard preprinted or partially preprinted accident prevention and operation tags, of plasticized card stock with matt finish suitable for writing, approximately 3¼-inch x 5-5/8-inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large size primary wording, e.g., DANGER, CAUTION, DO NOT OPERATE.



E. Baked Enamel Danger Signs:

1. Provide Manufacturer's standard "DANGER" signs of baked enamel finish on 20 gauge steel; of standard red, black and white graphics; 14-inch x 10-inch size except where 10-inch x 7-inch is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g. HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.



F. Engraved Plastic Laminate Nameplates:

1. Provide engraving stock melamine or phenolic plastic laminate, in sizes and thickness indicated, engraved with engraver's standard letter style of the sizes and working indicated, black face and white core plies (letter color) except as otherwise indicated on drawings, or where noted in the specification. Punch for mechanical fastening.
 - a. Thickness: 1/8-inch, except as otherwise noted.
 - b. Fasteners: Self-tapping stainless-steel screws or brass bolts.



G. Underground Type Plastic Line Marker:

1. Manufacturer's standard permanent, magnetic bright colored, continuous printed, metal backed plastic tape, intended for direct burial service; not less than 6-inches wide x 4 mils thick. Provide tape with printing which most accurately indicates the type of service or buried cable.



2.2 LETTERING AND GRAPHICS

A. General Installation Requirements:

1. Installation: Install electrical identification products as indicated, in accordance with Manufacturer's written instructions, and requirements of NEC®.
2. Coordination: Where identification is to be applied to surfaces which require a field finish application, install identification after completion of such application.
3. Regulations: Comply with governing regulations and requests of governing authorities for the identification of electrical work.

2.3 ACCEPTABLE ELECTRICAL IDENTIFICATION MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the City ten (10) days prior to bid date.

1. CARLTON INDUSTRIES, LP
www.carltonusa.com
(800) 231-5988
2. IDEAL® INDUSTRIES, INC.
www.idealindustries.com
(800) 435-0705
3. NATIONAL BAND AND TAG
www.nationalband.com
(859) 581-8247
4. PANDUIT® CORP.
www.panduit.com
(800) 777-3300
(708) 532-1800
5. SETON IDENTIFICATION PRODUCTS
www.seton.com
(800) 571-2596
6. THOMAS AND BETTS CO.
www.tnb.com
(888) 862-3289
7. City Preapproved Equal

2.4 LOCAL IDENTIFICATION MANUFACTURERS

A. These firms have been used in the past and provided products acceptable to the City

1. FLORIDA MARKING PRODUCTS INC.
www.floridamarking.com
(407) 834-3000
2. THE CUTTING EDGE

www.cuttingedgeinc.com

(800) 962-2376

(440) 259-2581

3. City Preapproved Equal

PART 3 - EXECUTION

3.1 RACEWAY SYSTEM IDENTIFICATION

A. Where electrical conduit is exposed in spaces with exposed mechanical piping, and the mechanical piping is identified by color-coding method, apply color-coded identification on electrical conduit in manner similar to piping identification. Orientation of all labels shall be of the same orientation.

1. Except as otherwise indicated, use white as the coded color for conduit.
2. Identify the following services:

<u>Service</u>	<u>Label</u>
a. Low Voltage	208/120V
b. High Voltage	480/277V

3.2 CABLE/CONDUCTOR IDENTIFICATION

- A. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication (such as color coded conductors) is provided. Match identification with marking system used in panel board, shop drawings, contract documents, and similar previously established identification for project's electrical work.
- B. Color code all power and lighting cable. Use wire colored by integral pigmentation, making the wire 100% colored. Where not practicable or available (in larger conductor sizes), color code the wire by using colored plastic tape, painting the ends accessible at junction or pull boxes, or other method acceptable to the Engineer. Use the following chart as applicable:

<u>Conductor</u>	<u>208/120V</u>	<u>480/277V</u>
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green with Yellow Tracer

3.3 OPERATIONAL IDENTIFICATION AND WARNINGS

- A. Wherever warning of electrically connected equipment exists, and signage would prevent misuse of electrical facilities by unauthorized personnel.

1. Install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes.
- B. Danger Signs:
1. Locations: In addition to installation of danger signs required by governing regulations and authorities, install appropriate danger signs at locations indicated and at location subsequently identified as constituting dangers for person in or about project.
 2. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than 120-Volts.
 3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss of property.
 4. Electrical Equipment Rooms: Provide warning signage at the entrance to each such room.
- C. Equipment Identification:
1. Nameplates: Install an engraved plastic laminate nameplate on each unit of electrical equipment in the building: including central or master unit of each electrical system including communication and/or control systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1-inch high white lettering in back field. Provide text matching terminology and numbering of the contract documents and shop drawings.
 2. Provide nameplates for each unit of the following categories of electrical work:
 - a. Panelboard, electrical cabinets and enclosures - Provide a nameplate inside, outside and above the door (if equipped with one) of each listing its designation, voltage and feeder and circuit number. Nameplate shall designate source and circuit number of feeder. (Label existing equipment located in same space or room as new equipment being installed.)
 - b. Access panel/doors to electrical facilities.
 - c. Major electrical switchgear, switchboards and motor control centers.
 - d. Disconnect switches.
 3. Install nameplates at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment.
 - a. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.

- b. Designate branch of essential power system (i.e. Life Safety, Critical, or Equipment branch) on nameplate after the word emergency, and board designation.
- c. Color code nameplates as follows:
 - i. General Information shall be Black;
 - ii. Circuit Information 120/208VAC shall be Gray;
 - iii. Circuit Information 277/480VAC shall be Orange

End of Section

Section 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE

- A. This Section describes the Basic Electrical Materials and Methods that shall be used throughout this project.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - a. Section 13310 - Programmable Logic Controller (PLC) and Digital Equipment;
 - b. Section 13315 – Field Instrumentation;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) C55.1 - Shunt Power Capacitors;
 - 2. ANSI C62.11 - Metal-Oxide Surge Arrestors for AC Circuits;
 - 3. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment;
 - 4. ANSI/ Society of Cable Telecommunications Engineers (SCTE) 77 - Specification for Underground Enclosure Integrity, Tier 8 (12,000# Test Load); Tier 15 (22,500# Test Load) and Tier 22 (33,750# Test Load);
 - 5. American Society for Testing and Materials (ASTM) A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip;
 - 6. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels;
 - 7. ASTM A570 - Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality;
 - 8. Federal Specifications (FS) W-C-596 - Connector, Receptacle, Electrical;
 - 9. FS W-C-596 - Electrical Power Connectors;
 - 10. FS W-S-896E - Switches, Toggle, Flush Mounted;
 - 11. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

12. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
13. NECA 420 - Standard for Fuse Applications;
14. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers;
15. National Electrical Manufacturers Association (NEMA) 250 - Enclosures for Electrical Equipment (1000-Volts Maximum);
16. NEC® Chapter 3 – Wiring Methods and Materials;
17. NEC® Article 450 – Transformers and Transformer Vaults (Including Secondary Ties);
18. NEC® Article 500 – Hazardous (Classified) Locations, Classes I, II and III, Division 1 and 2;
19. NEC® Article 501 – Class I Locations;
20. NEC® Article 504 – Intrinsically Safe Systems;
21. NEC® Article 505 – Class I, Zone 0, 1 and 2 Locations;
22. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches;
23. NEMA CP I - Shunt Capacitors;
24. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies;
25. NEMA KS 1 - Enclosed Switches;
26. NEMA LA I - Surge Arrestors;
27. NEMA PB 1 - Panelboards;
28. NEMA ST 20 - Dry-Type Transformers for General Applications;
29. NEMA WD I - General Requirements for Wiring Devices;
30. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
31. NFPA® 70E® - Electrical Safety in the Workplace;
32. NFPA® 72 - National Fire Alarm Code;
33. Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
34. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
35. UL 67 - Panelboards;
36. UL 98 - Enclosed and Dead-Front Switches;
37. UL 198C - Safety High-Interrupting-Capacity Fuses, Current-Limiting Types;
38. UL 198E - Class Q Fuses;
39. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements;
40. UL 248-2 - Low-Voltage Fuses - Part 2: Class C Fuses;
41. UL 248-3 - Low-Voltage Fuses - Part 2: Class C Fuses;
42. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses;
43. UL 248-5 - Low-Voltage Fuses - Part 5: Class G Fuses;
44. UL 248-6 - Low-Voltage Fuses - Part 6: Class H Non-Renewable;
45. UL 248-7 - Low-Voltage Fuses - Part 7: Class H Renewable Fuse;
46. UL 248-8 - Low-Voltage Fuses - Part 8: Class J Fuses;
47. UL 248-9 - Low-Voltage Fuses - Part 9: Class K Fuses;
48. UL 248-10 - Low-Voltage Fuses - Part 10: Class L Fuses;
49. UL 248-11 - Low-Voltage Fuses - Part 11: Plug Fuses;

50. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses;
51. UL 248-13 - Low-Voltage Fuses - Part 13: Semiconductor Fuses;
52. UL 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses;
53. UL 248-15 - Low-Voltage Fuses - Part 15: Class T Fuses;
54. UL 248-16 - Low-Voltage Fuses - Part 16: Test Limiters;
55. UL 310 - Electrical Quick-Connect Terminals;
56. UL 347 - Alternating Current Contactors and Contactor-Based;
57. UL 486A-486B - Wire Connectors;
58. UL 486C - Splicing Wire Connectors;
59. UL 486D - Sealed Wire Connector Systems;
60. UL 486E - Equipment Wiring Terminals;
61. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures;
62. UL 498 - Attachment Plugs and Receptacles;
63. UL 508A - Industrial Control Equipment;
64. UL 810 - Capacitors;
65. UL 943 - Ground-Fault Circuit Interrupters;
66. UL 1059 - Terminal Blocks;
67. UL 1561 - Dry-Type General-Purpose and Power Transformers;
68. UL 4248-1 - Fuseholders - Part 1: General Requirements;
69. UL 4248-4 - Fuseholders - Part 4: Class CC;
70. UL 4248-5 - Fuseholders - Part 5: Class G;
71. UL 4248-6 - Fuseholders - Part 6: Class H;
72. UL 4248-8 - Fuseholders - Part 8: Class J;
73. UL 4248-9 - Fuseholders - Part 9: Class K;
74. UL 4248-11 - Fuseholders - Part 11: Type C (Edison Base);
75. UL 4248-12 - Fuseholders - Part 12: Class R;
76. UL 4248-15 - Fuseholders - Part 15: Class T;
77. UL 62275 - Cable management systems - Cable ties for electrical;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. Shop Drawings:
 1. Device boxes for use in hazardous areas.
 2. Junction and pull boxes used at, or below, grade.
 3. Device box relocation.
 4. Terminal junction boxes.

5. Circuit breaker data.
6. Fuses.
7. Contactors.
8. Transformers.
9. All other miscellaneous material part of this project.
- E. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Cable terminal sizes;
 4. Component list;
 5. Wiring diagrams;
 6. Installation information;
- F. Quality Control Submittals:
 1. Test Report: Sound test certification for dry type power transformers (0 to 600-volt, primary).

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 2. The Electrical materials shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type the appropriate code into the Category Code search box and click Search.
- D. 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.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer’s instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SPARE PARTS

- A. Furnish, tag and box for shipment and storage the following spare parts:

1. Fuses, 0 to 600-Volts: Six of each type and each current rating installed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.2 ALTERNATOR

- A. Used in control panels where two loads are required to alternate to provide equal run time on the loads;
- B. The alternating action is initiated by a control switch, which is common with one side of the control voltage;
- C. The output contacts will change states each time the control switch is opened, thus alternating the two loads.
- D. Acceptable Alternator Manufacturer's:
 1. MARSH BELLOFRAM®
ATC DIVERSIFIED ELECTRONICS
www.marshbellofram.com
Part No. ARA-120-ACA, where
AR = Alternating Relay;
A = Standard Duplexor;
120 = 120VAC/DC Control Voltage;
A = VAC or VAC/DC Type;
C = DPDT (Cross Wired) Contacts;
A = "A" Lexan® Dust Cover Enclosure;
 2. MOTOR PROTECTION ELECTRONICS, INC.
www.mpelectronics.com
Part No. 008-120-13, where
008 = Alternator product Type;
120 = 120VAC operating Voltage;
13 = Relay Base Wiring;

2.3 ANTI-SEIZE/ANTI-CORROSION (COPPER) COMPOUND

- A. Copper anti-seize, anti-corrosion compound shall be applied to the threads of all bolts & screws prior to installation;
- B. The anti-seize, anti-corrosion compound shall be appropriate to the hardware material being assembled;
- C. Use on all types of threaded connections, bushings, keyways, press fits, etc. to protect against seizure, heat freeze, galling, rust and corrosion;
- D. Acceptable Anti-Seize/Anti-Corrosion (Copper) Manufacturer's:
 1. CRC® INDUSTRIES, INC.
www.crcindustries.com
Sta-Lube Copper Anti-Seize;
 2. HENKEL CORPORATION

- www.loctite.com
LOCTITE® C5-A®;
- 3. JET LUBE®
www.jetlube.com
KOPR-KOTE®;
- 4. PERMATEX®, A Division of ITW
www.permatex.com
Copper Anti-Seize;

2.4 BLOCKS, FUSE AND FUSES, 0 TO 600-VOLTS

- A. Current-limiting, with 200,000-ampere Root Mean Square (RMS) interrupting rating; Provide to fit mountings specified with switches and features to reject Class H fuses;
- B. Motor & Transformer Circuits, 0 to 250-Volts and 0 to 600-Volts - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
- C. Feeder and Service Circuits, 0 to 250-Volts and 0 to 600-Volts - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
- D. Feeder and Service Circuits, 0 to 600-Volts – Amperage 601 to 6,000-Volts; UL 198C, Class L, double O-rings and silver links;
- E. Control circuit specifics;
- F. Acceptable Blocks, Fuse and Fuses, 0 to 600-Volts Manufacturers
 - 1. COOPER BUSSMANN®
www.bussmann.com
 - 2. LITTELFUSE®
www.littelfuse.com
 - 3. MERSEN USA
www.mersen.com

2.5 BLOCKS, POWER DISTRIBUTION & SPLICE

- A. Power distribution blocks (PDBs);
- B. Short-circuit current rated (SCCR);
- C. UL1953 Listed;
- D. Acceptable Blocks, Power Distribution & Splice Manufacturers
 - 1. COOPER INDUSTRIES
www.cooperbussmann.com
 - 2. BUSSMAN® Series PDBFS;
 - 3. MARATHON SPECIAL PRODUCTS, INC.
www.marathonsp.com
Enclosed Power Blocks – EPB Series;
 - 4. MERSEN USA
www.mersen.com
Finger-Safe Power Distribution Blocks;
 - 5. ROCKWELL AUTOMATION
www.ab.com
Bulletin 1492 Power Distribution Terminal Blocks;

2.6 BLOCKS, TERMINAL COMPRESSION CLAMP

- A. Includes Blocks, End Sections, Jumpers, Stops, Markers, etc.; UL Listed;
- B. Acceptable Blocks, Terminal Compression Clamp Manufacturers
 - 1. MARATHON SPECIAL PRODUCTS, INC.
www.marathonsp.com
MIK10 and MIW16 DIN Rail Terminal Blocks and Accessories;
 - 2. PHOENIX CONTACT
www.phoenixcon.com
Control: Type UK10;
4-20mA: Type UK5-MTK-P/P;
Ground Shields: Type USLKGIO;
Ground Signal Shields: Type UKIO;
Ground: Type USLKG6N;
 - 3. ROCKWELL AUTOMATION
www.ab.com
Allen-Bradley IEC Screw-Type Terminal Blocks (J-Line);
 - 4. SIEMENS INDUSTRY
www.sea.siemens.com
ALPHA FIX 8WA and 8WH Terminals with Screw Connection
 - 5. WEIDMULLER
www.weidmuller.com
Type W-Series Clamping Yoke Screw Connection;

2.7 BOXES, JUNCTION AND PULL

- A. Concrete
 - 1. Box: Reinforced, cast concrete;
 - 2. Application appropriate: either Pedestrian or Traffic Rated;
 - 3. Cover: Cast iron;
 - 4. Cover marking: Marked ELECTRIC, GROUND TEST WELL, TELEPHONE, FIBER, CABLE, etc.;
- B. Acceptable Concrete Boxes, Junction and Pull Manufacturers
 - 1. CONCAST INC.
www.concastinc.com
Fibercrete®;
 - 2. OLDCASTLE PRECAST®
www.brooksproducts.net
BROOKS PRODUCTS;
 - 3. City Preapproved Equal
- C. Cast Metal
 - 1. Surface-mounted, Flush-mounted, Sidewalk-boxes, Aboveground Pull-N-Splice Boxes and Aboveground Pull Boxes for Non-hazardous (weatherproof, rainproof, watertight NEMA 4, submersible, dust-tight) and Hazardous (NEMA 7 or 9);
 - 2. Box: Cast metal box;
 - 3. Cover: Cast metal cover;
 - 4. Cover marking: Marked ELECTRIC, GROUND TEST WELL, TELEPHONE, FIBER, CABLE, etc.;
- D. Acceptable Cast Metal Boxes, Junction and Pull Manufacturers

1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Metallic Enclosures –
W Series; and RS, RSM and RSS Junction Boxes;
2. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type YG Cast Iron Junction Boxes;
3. City Preapproved Equal
- E. Stainless Steel
 1. NEMA 4X: Type 316 stainless steel (Continuous-hinge with clamps (bolted or screwed) covers with gaskets;
 2. If used for a terminal junction box, provide terminal strips or terminal blocks with a separate connection point for each conductor entering or leaving the box. Also, provide a minimum of 25% spare terminal points;
 3. ALL NEMA 4X Large (≥24-inch Height x 20-inch Wide) Wall-Mount shall have continuous-hinge with 3-Point Latch;
- F. Acceptable Stainless Steel Boxes, Junction and Pull Manufacturers
 1. PENTAIR TECHNICAL PRODUCTS
www.hoffmanonline.com
HOFFMAN® Stainless Steel Continuous Hinge Type 4X CHNFSS Junction Boxes
Continuous Hinge with 3-Point Latch, Type 4X SSLP3PT Enclosures
 2. RITTAL CORP.
www.rittal.com
NEMA 4X Junction Boxes;
 3. City Preapproved Equal
- G. Non-Metallic (Non-Hazardous and Hazardous)
 1. Aboveground Enclosures (i.e. Pull Box, Junction Box, Splice Box) –
 2. Underground Enclosures (i.e. Pull Box, Junction Box, Hand Hole, Splice Box) - Fiberglass/Polymer Concrete:
 - a. Lightweight;
 - b. Designed for Tier 8 (12,000lbs) applications;
 - c. Flared design provides added work space for easier conduit management;
 - d. Minimum 18" Depth;
 - e. Bolted Cover;
 - f. Cover Marking – as required (i.e. ELECTRIC, CONTROL, FIBER);
- H. Non-Metallic (Non-Hazardous and Hazardous) Boxes, Junction and Pull Manufacturers
 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
TBF/TBP Series N Glass-fiber Reinforced Polyester Enclosures;
Wall Mount & Large Fiberglass Enclosure Series
 2. PENTAIR TECHNICAL PRODUCTS
www.hoffmanonline.com

- HOFFMAN®
- ZONEX® ATEX-Certified, Type 4X;
- 3. RITTAL CORP.
www.rittal.com
ATEX Plastic Enclosures;
- 4. HIGHLINE PRODUCTS
www.highlineproducts.com
Composite Hand hole Assembly
CHA Series;
- 5. HUBBELL® POWER SYSTEMS
www.hubbellpowersystems.com
QUAZITE® Below Ground Flared CDR Style;
- 6. City Preapproved Equal

2.8 BOXES, OUTLET AND DEVICE

- A. Cast Metal
 - 1. Cast ferrous metal box;
 - 2. Suitable for use in wet locations when used with gasket and flat blank covers;
 - 3. Green ground screw located on the flange of the box for easy ground wire termination and is standard on boxes;
 - 4. Cast mounting lugs standard;
 - 5. Tapered threaded hubs (NPT) with integral bushing;
 - 6. Available as shallow (FS) or deep (FD) configuration;
 - 7. Heavy duty, gasketed, weatherproof, cast ferrous metal cover (or copper-free aluminum) with stainless steel screws;
- B. Acceptable Cast Metal Outlet and Device Box Manufacturers
 - 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type FS or FD;
 - 2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
Type FS or FD;
- C. Aluminum (Copper-free) Hazardous Location
- D. Acceptable Aluminum (Copper-free) Hazardous Location Outlet and Device Box Manufacturers
 - 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Condulet® Explosion-proof Conduit Outlet Boxes & Bodies;
 - 2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
Explosion-proof Conduit Outlet Boxes & Bodies;
- E. Metal/Aluminum DIN Mountable
 - 1. DIN mount Surge Protected Dual Outlet for 120VAC, 15A Service;

- F. Acceptable Metal/Aluminum DIN Mountable Outlet and Device Box Manufacturers
 - 1. HUBBELL® INC.
www.hubbell-wiring.com
Part No. DRUBTVSS15;
 - 2. PHOENIX CONTACT
www.phoenixcon.com
EM-DUO-120/15/SPD
Part No. 56 01 28 3;
- G. Non-Metallic
 - 1. Box: PVC;
 - 2. Cover: PVC, weatherproof, with stainless steel screws;
- H. Acceptable Non-Metallic Outlet and Device Box Manufacturers
 - 1. CARLON®
www.carlon.com
Type FS or FD Switch Boxes
with Type E98 or E96 covers;
 - 2. City Preapproved Equal

2.9 BUFFER MODULE

- A. With short-term power failures, the load current can be backed up without interruption via the buffer module in combination with the power supply. The buffer module is connected in parallel to the output of the power supply; Used in ALL PLC Panels in UPS Circuit; UL Listed;
- B. Acceptable Buffer Module Manufacturers
 - 1. SIEMENS INDUSTRY
www.automation.siemens.com
SITOP Buffer Module,
Part No. 6EP1 961-3BA00;
 - 2. NO EQUAL

2.10 CIRCUIT BREAKERS, INDIVIDUAL, 0 TO 600-VOLTS

- A. Molded case circuit breakers (MCCB) shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics;
- B. All circuit breakers shall be UL Listed 489 listed for use at location of installation;
- C. Conform to applicable requirements of NEMA Standard Publication No. AB1;
- D. Meet appropriate classifications of Federal Specifications W C 375B/Gen.;
- E. Minimum Interrupt Rating: As shown on the Contract Drawings or as required;
- F. Thermal-magnetic, quick-make, quick-break, indicating type, showing ON/OFF and TRIPPED indicating positions of the operating handle;
- G. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
- H. Locking: Provisions for padlocking handle;
- I. Multi-pole breakers shall automatically open all poles when an overload occurs on one-pole; Do not provide single-pole circuit breakers with handle

- ties where multi-pole circuit breakers are shown;
- J. Enclosure: NEMA 250, Type 12, Industrial Use, 4X, Corrosive, unless otherwise shown;
 - K. Acceptable Circuit Breakers, Individual, 0 to 600-Volts Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
 CUTLER-HAMMER®
 Thermal-Magnetic/ Electronic Trip;
 - 2. ROCKWELL AUTOMATION
www.ab.com
 ALLEN-BRADLEY®
 Thermal-Magnetic/ Electronic Trip;
 - 3. SCHNEIDER ELECTRIC
www.schneider-electric.us
 SQUARE D®
 Thermal-Magnetic/ Electronic Trip;
 - 4. SIEMENS INDUSTRY
www.automation.siemens.com
 SENTRON
 HG miniature –
 1-pole, 1A – 5SJ4101-7HG41;
 1-pole, 2A – 5SJ4102-7HG41;
 1-pole, 5A – 5SJ4111-7HG41;
 2-pole, 1A – 5SJ4201-7HG41;
 SENTRON
 Thermal-Magnetic/ Electronic Trip;

2.11 CONTACTOR, MECHANICAL (A.K.A. LIGHTING CONTACTOR)

- A. 3-pole; AC Lighting contactors do not change state and disconnect power from the load during a loss of control power; the operating coil is not required to be continuously energized;
- B. Acceptable Contactor, Mechanical (a.k.a. Lighting Contactor) Manufacturers
 - 1. ROCKWELL AUTOMATION
www.ab.com
 ALLEN-BRADLEY®
 Bulletin 500LC - Mechanically Held Multi-Pole Lighting Contactors;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
 Mechanically Held Contactors, Class CLM with 120VAC/60-Hertz coil;

2.12 CONTACTOR, VACUUM

- A. Electrically operated, mechanically held;
 - A. Main Contacts: Power driven in one direction with gravity dropout, Silver alloy with wiping action and arc quenchers, Continuous-duty, rated 30A, 600-volt, Three-pole;
 - B. Control: Two-wire; One NO and one NC auxiliary contacts rated 10A at 480-volt;

- C. Enclosure: NEMA 250, Type 12;
- D. Acceptable Contactor, Vacuum Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
 CUTLER-HAMMER®
 A200 Series (NEMA);
 - 2. ROCKWELL AUTOMATION
www.ab.com
 ALLEN-BRADLEY®
 NEMA Contactors;
 - 3. SIEMENS INDUSTRY
www.automation.siemens.com
 SIRIUS
 Vacuum Contactors, Class 40;

2.13 COUPLINGS, FLEXIBLE FOR HAZARDOUS LOCATIONS

- A. UL Listed;
- B. Acceptable Couplings, Flexible for Hazardous Locations Manufacturers
 - 1. EGS ELECTRICAL GROUP
www.o-zgedney.com
 O-Z/GEDNEY
 Type ECGJH;
 - 2. ADALET,
 A SCOTT FETZER CO.
www.adalet.com
 PECO Explosion-Proof Flexible Couplings;

2.14 DISCONNECT, SERVICE

- A. Used by Lift Stations for Duplex & Triplex outdoor <50HP applications;
- B. Complete assembly consists of a thermal magnetic molded case circuit breaker (MCCB), trip unit, NEMA 4X stainless steel enclosure and lugs;
- C. Service Disconnect shall be listed as suitable for service entrance application by UL;
- D. Acceptable Service Disconnect Manufacturers
 - 1. EATON CORPORATION
www.eaton.com
 MCCB, Series C, F-Frame Thermal-Magnetic 125–250A
 Part No. HJDP999, where:
 HJD = Circuit Breaker/Frame Type;
 P = 2 or 3 poles;
 999 = Trip unit size;
 And
 Enclosure
 Part No. WJDN250, where:
 W = 4/4X Stainless Steel;
 JDN = Series C Breaker “HJD”;
 225 = 125 to 225A Breaker Range;
 - 2. SIEMENS INDUSTRY

www.automation.siemens.com

Enclosed Circuit Breaker,

Part No. E4XFXD6PB999, where:

E4X = Type 4X Stainless Steel Enclosure;

FXD6 = SENTRON Breaker Frame, P = 2 or 3 poles;

B999 = Trip unit size;

2.15 ENCLOSURES

- A. All enclosures shall have a continuous hinge;
- B. All enclosures shall have a 3-point latch;
- C. All NEMA 12 (dust-tight, intended for indoor use primarily to provide protection against circulating dust, falling dirt and dripping non-corrosive liquids) wall, channel-mounted or free-standing enclosures shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Continuous Hinge Door(s) with 3-Point Latch(es), Steel Padlocking Handle; 80% minimum of panel interior exposed by doors; Equipped with hand-switch controlled, 40-watt fluorescent light and 120V, 15A duplex utility receptacle, serviced through a dedicated breaker; Each door equipped with a print pocket; Nameplate; Conditioned Interior Location shall be NEMA 12;
- D. All NEMA-3R (rain tight, intended for outdoor use primarily to provide protection against rain, sleet and damage from external ice formation) Lift Stations electrical panels shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Weatherproof with Continuous Hinge Door(s) with 3-Point Latch(es) with dead front panel, separate removable inside panel and Stainless Steel Padlocking Handle;
- E. All NEMA 4X (watertight, intended for indoor or outdoor use to provide protection against windblown dust and rain, splashing rain, hose-directed water, and damage from external ice formation) wall, channel-mounted or free-standing enclosures shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Continuous Hinge Door(s) with 3-Point Latch(es), Stainless Steel Padlocking Handle; 80% minimum of panel interior exposed by doors; Equipped with hand-switch controlled, 26-watt LED, 4000K light and 120V, 15A duplex utility receptacle, serviced through a dedicated breaker; Each door equipped with a print pocket; Nameplate; Non-conditioned Interior Location shall be NEMA 4X; Exterior Location shall be NEMA 4X Full sun shields and be painted white;
- F. Acceptable Control Panel Enclosure Manufacturers
 - 1. www.hoffmanonline.com
NEMA 12
Concept® Type 12 Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch;
Type 12 Free-Stand Enclosures; Type 12 Floor-Mount Enclosures; all with 3-Point Latches;
All NEMA-3R
NEMA 4X
Stainless Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch; Or

- Stainless Steel Free-Standing Single or Dual Access Enclosures with 3-Point Latches;
- 2. RITTAL CORP.
www.rittal.com
 NEMA 12
 Compact AE Single or Double Door Enclosures, Continuous Hinge with 3-point Latch; or
 TS 8 Baying Systems;
 All NEMA-3R;
 NEMA 4X
 WM Wall-mount Enclosures with Accessory Part No. WMLHKLS6 – 8018691 L Handle for WM 3 Point Latch, Pad-lockable, Stainless Steel 316L;

2.16 ENCLOSURES, ACCESSORIES

- A. Control Panel Enclosure Temperature/Humidity Controls;
 - 1. Properly sized and selected to meet and maintain all requirements;
- B. Acceptable Control Panel Enclosure Temperature/Humidity Control Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
 Thermal Management Products Corrosive/Outdoor Series CR29
 - 2. RITTAL CORP.
www.rittal.com
 System Climate Control Products;
 - 3. PFANNENBERG INCORPORATED
www.pfannenberguna.com
 Stainless Steel (316) / Washdown 4/4X Cooling Units;
- C. Control Panel Enclosure Corrosion Inhibiting Vapor Capsules
 - 1. Vapor capsules emit powerful corrosion inhibiting molecules into an enclosure that settle on metal surfaces and protect them from corrosion;
- D. Acceptable Control Panel Enclosure Corrosion Inhibiting Vapor Capsule Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
 Industrial Corrosion Inhibitors,
 Part No. A-HClxxxx;
 - 2. NORTHERN TECHNOLOGIES INT'L CORP.
www.ntic.com
 Part No. Zerust® ICT® VCx-x;
 - 3. City Preapproved Equal
- E. Control Panel Enclosure Corrosion Inhibitor Emitter
 - 1. Emitters are unique devices designed to provide corrosion protection for metal components and parts enclosed in non-ventilated control boxes, cabinetry or tool boxes. These devices emit vapors, which deposit a molecular layer on internal metal surfaces to protect critical, complex and expensive electronic equipment during operation,

- shipping or storage. Provides long-term protection against corrosion even in the presence of adverse conditions including salt, moisture, airborne contaminants, H₂S, SO₂, NH₃ and others;
- F. Acceptable Control Panel Enclosure Corrosion Inhibitor Emitter Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
Industrial Corrosion Inhibitors,
Part No. A-HC15E;
 - 2. CORTEC® CORPORATION
www.cortecvci.com
Vapor phase Corrosion Inhibitors,
Part No. VpCI-111;
 - 3. City Preapproved Equal
 - G. Control Panel Enclosure Combination Drain/Breather
 - 1. This device provides ventilation to minimize condensation; drain accumulated condensate;
 - H. Acceptable Control Panel Enclosure ½-inch Combination Drain/Breather Manufacturers
 - 1. COOPER
www.crouse-hinds.com
CROUSE-HINDS®
Part No. ECD18;
Breather Only, Part No. ECD13;
Drain Only, Part No. ECD11;
 - 2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
Part No. Type DB;
Breather Only, Part No. BRT4X;
Drain Only, Part No. ECD50B4X;
 - 3. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
H2OMIT® Stainless Steel Vent Drain, Type 4X,
Part No. AVDR4SS4;
Stainless Steel Pressure Compensation Device, Type 4X,
Part No. APCDSS6;
 - I. Control Panel Enclosure LED Lighting Fixtures
 - 1. All control panels shall include a lighting fixture for each door;
 - J. Acceptable Control Panel Enclosure LED Lighting Fixtures Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
PANELITE™ LED Enclosure Light, Part No. LED24V15;
 - 2. RITTAL CORP.
www.rittal.com
10/20/30/40-LED System Lights
Part No. 4140810, 4140820, 4140830, or 4140840;
 - K. Control Panel Enclosure Window Kits

1. ABC
- L. Acceptable Control Panel Enclosure Window Kit Manufacturers
 1. CARLON®
www.carlon.com
Circuit Safe® NEMA 4X Rated Window Kits;
 2. FIBOX ENCLOSURES
www.fiboxusa.com
Inspection Windows or
Instrument Protection Windows;
 3. City Preapproved Equal
- M. Control Panel Enclosure Disconnect, Door Mounted
 1. UL Listed;
- N. Acceptable Control Panel Enclosure Disconnect, Door Mounted Manufacturers
 1. SIEMENS INDUSTRY
www.sea.siemens.com
Max-Flex™ Flange Mounted Variable Depth Operators;
 2. City Preapproved Equal

2.17 ENCLOSURES, PAD-MOUNT ELECTRICAL

- A. Construction: 12 gauge mild steel or aluminum construction; stainless steel available); Type 316 stainless steel hinges, padlock hasp and penta-head bolt latch; Panels available in off-set or in-line configuration and offered in stainless steel, mild steel and galvalume;
- B. Finish: Munsell green 7GY3.29/1.5 polyester powder finish inside and out over phosphatized surfaces; Mounting panels have white polyester powder paint over phosphatized surfaces;
- C. Industry Standards: ANSI C57.12.28 Pad-Mounted Equipment Enclosure Integrity;
- D. Standard Offering Includes: Choice of single- or three-phase enclosures; Interlocked recessed penta-head latch/padlock provision for tamper resistance; Self-engaging stop to hold cover in open position; Two stops provided if B dimension is greater than or equal to 42 inches; Ground nut provision for each phase; 5/8-11 threaded lifting provisions;
- E. Acceptable Enclosures, Pad-Mount Electrical Manufacturers
 1. DURHAM COMPANY
www.durhamcompany.com
Pad-Mount Enclosures;
 2. PENTAIR TECHNICAL PRODUCTS
www.hoffmanonline.com
HOFFMAN® Utility Junction (UJ) Sectionalizing Enclosures

2.18 GROUNDING BARS

- A. Acceptable Grounding Bars Manufacturers
 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®

- Part No. GBKxx (where xx = 05, 10, 13, 14, 21 terminals) - Ground Bar Kits;
2. ILSCO
www.ilsco.com
 D167 Ground Bars,
 Part No. D167-x (where x = 4, 6, 8, 10, 12, and 14 terminals);
 3. SCHNEIDER ELECTRIC
www.schneider-electric.us
 SQUARE D®
 Part No. PKxGTA (where x = 7, 9, 12, 15, 18, 23, 27 terminals) Load Center Ground Bar Assembly;
 4. SIEMENS INDUSTRY
www.sea.siemens.com
 ECGB Series
 5, 10, 14, or 20 Position Kits;

2.19 MECHANICAL INTERLOCKS

- A. Prevent Paralleling of Lines;
- B. Acceptable Mechanical Interlocks Manufacturers
 1. KIRK® KEY INTERLOCK COMPANY
www.kirkkey.com
 Original Brass Interlocks;
 2. SUPERIOR INTERLOCK CORPORATION
www.superiorinterlock.com
 Superior Locking Units;

2.20 METERS, ELAPSED TIME

- A. 2-inch Face Diameter Cut-out, Semi-flush panel mounting, NEMA 4X;
- B. Synchronous motor drive;
- C. 0 to 99,999.9 hours (6-digit), non-reset type;
- D. Acceptable Meters, Elapsed Time Manufacturers;
 1. ENM COUNTING INSTRUMENTS
www.enmco.com
 T40 3-Hole Quartz DC Hour Meter;
 T50 3-Hole Quartz AC Hour Meter;
 2. GENERAL ELECTRIC
www.geindustrial.com
 Type 240, 2-½ -inch Big Look;
 3. ELECTRO-METERS manufactures the YOKOGAWA 240 Series ETM
www.electro-meters.com
 4. TRUMETER TECHNOLOGIES LTD.
www.trumeter.com
 Redington Model 722 (732) Totally Sealed AC (DC) Hour Meter;
 TRUMETER acquired REDINGTON COUNTERS, INC. in 8/2011

2.21 MINI-POWER CENTER

The mini-power center shall be comprised of a primary main breaker, an encapsulated dry-type transformer and a panelboard with a secondary main breaker;

- A. Furnish and install a single-phase and three-phase general purpose individually mounted mini-power centers of the two-winding type, self-cooled, as specified herein and as shown on the Contract Drawings.
- B. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.
- C. Ratings:
 - 1. kVA and voltage ratings shall be as shown on the Contract Drawings;
 - 2. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96;
 - 3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
 - a. Up to 9 kVA 40 db;
 - b. 10 to 30 kVA 45 db;
 - c. 40 to 150kVa 50 db;
- D. Construction:
 - 1. Each mini-power center shall include a primary main breaker, an encapsulated dry-type transformer and a panelboard with secondary main breaker;
 - 2. Primary main, secondary main and feeder breakers shall be enclosed with a padlockable hinged door;
 - 3. Mini-power centers shall be suitable for service entrance application;
 - 4. Insulation Systems -
 - a. Transformers shall be insulated with a 185 °C insulation system and rated at 115 °C temperature rise;
 - b. Required performance shall be obtained without exceeding the above-indicated temperature rise in a 40 °C maximum ambient, with a 30 °C average over 24-hours;
 - c. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635;
 - 5. Core and Coil Assemblies -
 - a. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction;
 - b. The core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level;

- c. The core of the transformer shall be grounded to the enclosure;
 - d. Provide two (2) 5% FCBN taps;
- E. Bus:
 - 1. Secondary bus shall be copper.
- F. Wiring/Terminations
 - 1. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer and distribution section shall be factory installed;
 - 2. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring;
- G. Main Breakers - Each mini-power center shall include a primary main breaker with an interrupting rating of ≥ 14 kA at 277/480 volts; and a secondary main breaker with an interrupting rating of 10kA at 120/240 volts, and a panelboard;
- H. Feeder Breakers - The secondary distribution section shall use ONLY $\square$ bolt-on breakers with 10 kA interrupting capacity;
- I. Enclosure
 - 1. The enclosure shall be made of stainless steel and the maximum temperature of the enclosure shall not exceed 90 °C;
 - 2. The enclosure shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes;
- J. Acceptable Mini-Power Center Manufacturers
 - 1. EATON CORPORATION
www.eaton.com
Mini-Power Center;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
Sentron® Power Zone;
 - 3. **SQUARE D Mini Power Zone**

2.22 MONITORS, PHASE

- A. Used to detect and alarm under voltage, phase loss, phase reversal and phase unbalance;
- B. Specifications:
 - 1. Proper voltage indication and relay energized;
 - 2. Abnormal condition (Under Voltage, Phase issues) indication and relay de-energized;
 - 3. 200-240V or 425-525V;
 - 4. Delta or Wye
 - 5. 10A Resistive (6A Inductive) @240VAC Output Relay Rating;
 - 6. -40 to 122 °F (-40 to 50 °C) Operating Temperature;
 - 7. UL Listed;
- C. Acceptable Monitors, Phase Manufacturers
 - 1. MOTOR PROTECTION ELECTRONICS, INC.
www.mpelectronics.com
Part No. 001-VVV-1212, where:
001 = Product Type, Phase Monitor;
VVV = Operating Voltage, 230 or 480VAC;

- 12 = Relay Type, DPDT;
- 12 = 12-pin Base;
- 2. City Preapproved Equal

2.23 MOUNTING RAIL, PRE-PUNCHED DIN RAIL

- A. 6.5-feet - 1.37-inch x 0.29-inch x 0.03-inch (2-m – 35-mm x 7.5-mm x 1-mm), Chromated;
- B. Acceptable Mounting Rail, Pre-Punched DIN Rail Manufacturers
 - 1. ROCKWELL AUTOMATION
www.ab.com
 ALLEN-BRADLEY®
 Bulletin 1492,
 Part No. 199-DR1;
 - 2. SIEMENS INDUSTRY
www.sea.siemens.com
 Part No. 5ST 145;
 - 3. WEIDMULLER
www.weidmuller.com
 Part No. 51450;
 - 4. City Preapproved Equal

2.24 POWER SUPPLIES

- A. UL Listed; DIN rail mount;
- B. Acceptable Power Supply Manufacturers
 - 1. PULS
www.pulspower.com
 Mini-Line Single-phase, 2.5A, 30-watt,
 Part No. ML30.102;
 up to 84% Efficiency;
 Mini-Line Single-phase, 2.1A, 100-watt,
 Part No. ML100.105;
 up to 91.5% Efficiency;
 Silver-Line Single-phase, 5A, 240-watt,
 Part No. SL10.101;
 up to 90.4% Efficiency;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
 LOGO! Series –
 Part No. 6EP1 321-1SH02 1.9A;
 Part No. 6EP1 322-1SH02 4.5A;
 SITOP Series -
 Part No. 6EP1 332-2BA10 2.5A;
 Part No. 6EP1 333-2BA01 5A;
 Part No. 6EP1 334-2BA01 10A;
 - 3. EMERSON ELECTRIC CO.
 SOLA-HD POWER SUPPLIES
www.sola-hevi-duty.com
 SCP Series, 2.5A, 30-watt,

Part No. SCP 30S12-DN;
>=75% Efficiency;
SFL Series, 1.5A, 75-watt,
Part No. SFL1.5-48-100;
+85% Efficiency;
SFL Series, 6A, 300-watt,
Part No. SFL6-48-100;
+85% Efficiency;

2.25 PUSHBUTTONS, INDICATING LIGHTS AND SELECTOR SWITCHES

- A. General: 30.5 mm mounting hole; Corrosion Resistant, Water-tight, Oil-tight; Contact Rating: NEMA ICS 2, Type A600, 10A Continuous; LED Illumination ONLY; Lamp colors: ON = Green, FAULT = Red; Pushbutton Color;
- B. Acceptable Pushbuttons, Indicating Lights and Selector Switches Manufacturers
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type E-30;
 - 2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 800T/H 30.5mm NEMA;
 - 3. SCHNEIDER ELECTRIC
www.schneider-electric.us
SQUARE D® Class 9001, Type SK
For SHUNT TRIP –
SQUARE D®
SS Box - 9001 KYSS1;
Station - 9001 K15;
Contacts - 9001 KA1;
For Guarded E-STOP –
SQUARE D®
SS Box,
Part No. 9001 KYSS100;
PB Operator,
Part No. 9001 KR9P38LRR05H13 (120VAC) or
Part No. 9001 KR9P35LRR05H13 (24VDC);
LED,
Part No. 9001 6508805201;
ESTOP Guard,
Part No. 9001 K685;
 - 4. SIEMENS INDUSTRY
www.automation.siemens.com
Black Max, Class 52;
For Guarded E-STOP –
SS Box,

- Part No. P30EMS014;
PB Operator,
Part No. 52PX2GRAY (120VAC) or Part No. 52PE2DRA (24VDC);
Contacts,
Part No. 52BJK (24VDC);
LED,
Part No. 52AEB2 (120VAC) or
Part No. 52AEDB (24VDC);
Legend,
Part No. 52NL16R;
ESTOP Guard,
Part No. SQUARE D 9001K685;
5. KIM CONTROLS
www.kim-controls.com
Part No. 1A/SAR3/100MH120/BL-P;
- C. Watertight Selector Maintained Switches:
1. Units shall be heavy-duty, watertight, industrial type selector long lever switches;
 2. Contacts rated for 120VAC at 10A continuous;
 3. NEMA 4X watertight, corrosion-resistant;
 4. 30mm standard size, black field and legend plates with white markings, as indicated;
 5. Operators shall be black knob type;
 6. 2-position 1NO + 1NC; 3-position 2NO + 2NC;
 7. Single hole mounting, accommodating panel thickness from 1/16-inch minimum to 1/4-inch maximum;
- D. Acceptable Watertight Selector Maintained Switch Manufacturers
1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type E-34;
2-pos. Part No. E34VFBL1-1X;
3-pos. Part No. E34VHBL1-2X;
 2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 800T,
2-pos. Part No. 800T-H17A;
3-pos. Part No. 800T-J17A;
 3. SCHNEIDER ELECTRIC
www.schneider-electric.us
SQUARE D® Class 9001, Type SK
 4. SIEMENS INDUSTRY
www.automation.siemens.com
Black Max, Class 52;
2-pos. Part No. 52SW2AABA1;
3-pos. Part No. 52SW2CABA2;
- E. Watertight Illuminated Momentary Lamps/Pushbuttons:

1. Units shall be heavy-duty, watertight, industrial type push-to-test pushbutton;
 2. Contacts rated for 120VAC at 10A continuous;
 3. NEMA 4X watertight, corrosion-resistant;
 4. Screwed-on prismatic lenses in colors as shown;
 5. 30mm standard size, black field and legend plates with white markings, as indicated;
 6. Integrated LED module;
 7. Provide contact arrangements as shown;
 8. Single hole mounting, accommodating panel thickness from 1/16-inch minimum to 1/4-inch maximum;
- F. Watertight Illuminated Momentary Lamp/Pushbutton Manufacturers
1. EATON CORPORATION
www.eaton.com
 CUTLER-HAMMER®
 Type E34;
 Part No. E34FPB297L with
 Red Lens Part No. E34V2, or
 Green Lens Part No. E34V3;
 2. ROCKWELL AUTOMATION
www.ab.com
 ALLEN-BRADLEY®
 Bulletin 800H;
 Red Part No. 800H-QRBH2R;
 Green Part No. 800H-QRBH2G;
 3. SCHNEIDER ELECTRIC
www.schneider-electric.us
 SQUARE D® Class 9001, Type SK
 4. SIEMENS INDUSTRY
www.automation.siemens.com
 Black Max, Class 52;
 Red 120V Part No. 52BT6M2A;
 Red 24VDC Part No. 52BT6L2A;
 Green 120V Part No. 52BT6M3A;
 Green 24VDC Part No. 52BT6L3A;

2.26 RELAYS, CONTROL

- A. Variants:
1. Plug-in relays - Standard square base with full featured relay shall include dust cover, LED and mechanical flag indication, push-to-test button and typically a latching hold down door which provides a method of activating the contacts without applying power to the coil; Application specific - Contacts (SPDT, DPDT), Contact Rating (in Amperes), and Coil Voltage (in Volts);
 2. Machine-tool relays – Contactor relays with multiple poles (NO, NC);
 3. Time-delay relays - These relays combine an internal electronic or pneumatic timer with an electromechanical or solid state output. Single-function and field-programmable multi-function types are

offered. Timing modules typically control an external relay that switches the load.

B. Acceptable Relays, Control Manufacturers

1. OMRON
www.omron.com
120VAC Coil, SPDT, NO/NC contacts, 10 amp contact rating –Base:
Part No. P2RF-05-E
Relay: Part No. G2R-1-SN-AC120S;
24VDC Coil, SPDT, NO/NC contacts, 10 amp contact rating –
Base: Part No. P2RF-05-E
Relay: Part No. G2R-1-SN-DC24S;
2. OMRON
www.omron.com
Series H3, SSAC type TDM
3. PHOENIX CONTACT
www.phoenixcon.com
120VAC Coil, SPDT, NO/NC contacts, 10 amp contact rating –
Part No. 5520705;
24VDC Coil, SPDT, NO/NC contacts, 10 amp contact rating –
Part No. 5520695;
4. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY® Bulletin 700-HB Square Base Relay;
Bulletin 700-CF Control Relays;
5. SIEMENS INDUSTRY
www.sea.siemens.com
SIRIUS 3TX71 Plug-in Relays –
Relay Base and “Premium” Relay;
SIRIUS 3RH Contactor 4- and 8-pole Relays;
6. SIEMENS INDUSTRY
www.sea.siemens.com
Series 3RP;
7. TYCO ELECTRONICS
POTTER & BRUMFIELD
www.tycoelectronics.com
KUMP Series Panel Plug-in Relay;
8. TYCO ELECTRONICS
www.tycoelectronics.com
AGASTAT Series 7000;

2.27 RELAYS, INTRINSICALLY SAFE

- A. Reference Section 13315 – Field Instrumentation; UL Listed;
1. REFERENCE
SECTION 13315
FIELD INSTRUMENTATION;
INTRINSICALLY SAFE RELAYS FOR HAZARDOUS LOCATIONS
 2. NO EQUAL

2.28 STARTERS

- A. AC motor starters are used to turn-on and turn-off electric motors and motor-controlled equipment. An electric motor starter applies voltage directly to motor terminals to “start” the motor;
- B. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, Size 3;
- C. Horsepower rated at 600 volt, UL labeled for 65,000 amperes with overload protection;
- D. Three-phase, Full-Voltage, non-reversing, unless otherwise shown;
- E. Rated equal to or greater than the AIC rating of the gear;
- F. Solid state electronic overload relay with NEMA Class trip curves;
- G. Acceptable Starter Manufacturers;

1. EATON CORPORATION

www.eaton.com

Freedom NEMA Series;

Part No. AN19KN0A5E100;

where:

A = Device Type, Starter;

N = Standard, NEMA;

1 = Device Assembly Configuration, Non-reversing;

9 = OLR Type, Starter w/ C440 electronic overload;

K = Contactor Frame Size, NEMA 3 90A Continuous;

N = NEMA Enclosure, Open;

0 = Starter Mounting Option, Horizontal;

A = AC Coil Suffix, 120-Volt/60-Hertz;

5E = C440 OLR Designation, Standard feature set - SEL Reset, SEL Class (10A, 10, 20, 30);

100 = C440 FLA Range, NEMA Size 3 20-100A;

2. ROCKWELL AUTOMATION

www.ab.com

ALLEN-BRADLEY® Bulletin 509 Open Type Full Voltage Starter:

Part No. 509-DOD- A2L-99;

where:

509 = Bulletin No., Top-wired contactor;

D = NEMA Size, 3

O = NEMA Enclosure Type, No enclosure;

D = Nominal Coil Voltage, 120VAC/60-Hertz;

A2L = E1 Plus Solid-State Overload Relay, NEMA Size 3 18...90A Full Load Current Adjustment Range;

99 = Modifications/Options;

3. SIEMENS INDUSTRY

www.automation.siemens.com

ESP200® Heavy Duty Motor Starter with Solid State Overload with Auto/Manual Reset, Class 14;

Part No. 14GUG32AF;

where:

14 = Class, Across the Line NEMA Motor Starter;

G = Size, 2 1/2 NEMA;

U = Model, Size 00-4, 7&8;
G = Current Range, 25A-100A;
3 = Enclosure Size, 3-poles - 3-phase;
2 = Pilot Control Circuit, suitable for 3-wire control (NO aux. contact incl.);
A = Enclosure Type, Open;
F = Coil, 120V@60Hz;

4. **SQUARE D – NEMA Type S**

2.29 **SUPPLEMENTARY PROTECTORS**

- A. Supplemental protectors provide additional protection along with a branch circuit protection device.
- B. Certified to UL 1077;
- C. Acceptable Supplementary Protectors Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
WMZS UL 1077 Supplementary Protectors;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
5SY4 UL 1077 Supplementary Protectors

2.30 **SWITCHES, DOUBLE-THROW FUSED, 0 TO 600-VOLTS**

- A. Typically used for switching one load between two power sources;
- B. All double-throw fused switches shall be UL Listed;
- C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
- D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
- E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
- F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
- G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
- H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
- I. Include power source auxiliary contacts (1 NO, 1 NC) to enable City to monitor status;
- J. Acceptable Switches, Double-Throw Fused, 0 to 600-Volts Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Double-Throw Fused,
Part No. DTxxxFWKX;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
Type DTF
Double-Throw Fused,

Part No. FxxxSSDTK;
3. **SQUARE D – Double Throw - Fused**

2.31 **SWITCHES, DOUBLE-THROW NON-FUSED, 0 TO 600-VOLTS**

- A. Typically used for switching one load between two power sources;
- B. All double-throw non-fused switches shall be UL Listed;
- C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
- D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
- E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
- F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
- G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
- H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
- I. Include power source auxiliary contacts (1 NO, 1 NC) to enable City to monitor status;
- J. Acceptable Switches, Double-Throw Non-fused, 0 to 600-Volts Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Double-Throw Un-fused,
Part No. DTxxxUWKX;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
Type DTNF
Double-Throw Un-fused,
Part No. DTNFxxxS;
 - 3. **SQUARE D – Double Throw – Non-fused**

2.32 **SWITCHES, SINGLE-THROW FUSED, 0 TO 600-VOLTS**

- A. Typically used as a means to manually connect or disconnect the load from the source;
- B. All single-throw fused switches shall be UL Listed;
- C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
- D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
- E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
- F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
- G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

- H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
- I. Acceptable Switches, Single-Throw Fused, 0 to 600-Volts Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Fused,
Part No. DHxxxFWK316;
 - 2. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER® Fused,
Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
Use with 480VAC Electric Motor Actuators at all lift stations;
Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
Qty 2 ROs – Open & Close Commands;
 - 3. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER® Fused,
Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
Use with 480VAC Electric Motor Actuators at all treatment facilities;
 - 4. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII
Fused,
Part No. HFxxxSS;
 - 5. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII Fused,
Part No. HFxxxSS; SPD installed,
1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
Use with 480VAC Electric Motor Actuators at all lift stations;
Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
Qty 2 ROs – Open & Close Commands;
 - 6. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII Fused,
Part No. HFxxxSS; SPD installed,
1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
Use with 480VAC Electric Motor Actuators at all treatment facilities;
 - 7. **SQUARE D – Safety Switch - Fused**

2.33 SWITCHES, SINGLE-THROW NON-FUSED, 0 TO 600-VOLTS

- A. Typically used as a means to manually connect or disconnect the load from the source;
- B. All single-throw non-fused switches shall be UL Listed;
- C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
- D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
- E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
- F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
- G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
- H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
- I. Acceptable Switches, Single-Throw Non-fused, 0 to 600-Volts Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Unfused,
Part No. DHxxxUWK316;
 - 2. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER® Unfused,
Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
Use with 480VAC Electric Motor Actuators at all lift stations;
Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
Qty 2 ROs – Open & Close Commands;
 - 3. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER® Unfused,
Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
Use with 480VAC Electric Motor Actuators at all treatment facilities;
 - 4. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII
Unfused,
Part No. HNFxxxSS;
 - 5. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).

- Use with 480VAC Electric Motor Actuators at all lift stations;
Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
Qty 2 ROs – Open & Close Commands;
- 6. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
Use with 480VAC Electric Motor Actuators at all treatment facilities;
- 7. **SQUARE D – Safety Switch – Non-fused**

2.34 TRANSFORMERS, CONTROL POWER

- A. Control Power Transformer (CPT) features shall include:
 - 1. CPT for all low voltage control panel applications shall be sized per motor space heater requirements, minimum 500VA;
 - 2. CPTs for Motor Control Center (MCC) applications shall be sized per motor horsepower (i.e. the largest CPT that will fit within the bucket); the minimum shall be provided:
 - a. 150VA shall be used for less than 25HP;
 - b. 250VA shall be used for up to 100HP;
 - c. 500VA shall be used for all above 100HP;
 - 3. Two winding, 480VAC primary, 120VAC secondary voltage;
 - 4. Three-pole circuit breaker protection for primary;
 - 5. Single-pole circuit breaker protection for secondary;
 - 6. Single-pole circuit breaker protection for motor space heater;
 - 7. Suitable for use with 194 °F (90 °C) wire at full ampacity;
 - 8. UL 506 Listed;
- B. Acceptable Transformers, Control Power Manufacturers;
 - 1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type MTE;
 - 2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 1497B;
 - 3. SIEMENS INDUSTRY
www.sea.siemens.com
Class MT;
 - 4. **SQUARE D – Control Power Transformers**

2.35 TRANSFORMERS, DRY TYPE LIGHTING

- A. 480VAC, 3-phase Primary and
 - 1. UL 1561, NEMA ST 20;
 - 2. Self-cooled, two-winding, UL K-4 rated for nonlinear loads;
 - 3. Insulation Class and Temperature Rise: Manufacturer's standard;
 - 4. Core and Coil –

- a. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA;
 - b. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above;
- 5. Enclosure –
 - a. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated;
 - b. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated;
 - c. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated;
 - d. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated;
 - e. Outdoor Transformers: NEMA 250, Type 3R;
- 6. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA;
- 7. Voltage Taps –
 - a. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - b. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - c. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - d. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
- 8. Impedance: 4.5 percent minimum on units 75 kVA and larger;
- 9. Maximum Sound Level per NEMA ST 20 –
 - a. 40 decibels for 0 to 9 kVA;
 - b. 45 decibels for 10 to 50 kVA;
 - c. 50 decibels for 51 to 150 kVA;
 - d. 55 decibels for 151 to 300 kVA;
 - e. 60 decibels for 301 to 500 kVA;
- 10. Vibration Isolators –
 - a. Rated for transformer's weight;
 - b. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer;
 - c. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators;
 - d. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator;
- B. Acceptable Transformers, Dry Type Lighting Manufacturers
 - 1. EATON CORPORATION
www.eaton.com
 NEMA Premium® Efficient Transformers;
 - 2. SIEMENS INDUSTRY
www.sea.siemens.com
 NEMA Premium® Efficient Transformers;
 - 3. **SQUARE D – NEMA Premium Efficiency Transformers**

2.36 WALL SWITCHES

- A. Wall switches shall be flush-mounting, quiet type; All switches shall conform

- to Federal Specification WS-896-E;
- B. Single-Pole, Double-Pole, 3-Way, 4-Way, toggle switch, 120/277 VAC, 20A; NEMA WD 1 & 6; UL 20; 10-Year Limited Warranty; Color to be specified by City;
 - C. Acceptable Single-Pole, Double-Pole, 3-Way, 4-Way, toggle switch Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
AC Quiet Toggle Switches,
Model No. 122x Series;
 - 2. LEVITON
www.leviton.com
Heavy Duty AC Toggle Switches,
Model No. 122x Series;
 - 3. City Preapproved Equal
 - D. Single-Pole, Double-Pole, 3-Way, key-operated, 120/277VAC, 20A; nickel-plated lock dome, NEMA WD 1 & 6; UL 20; Color to be specified by City;
 - E. Acceptable Single-Pole, Double-Pole, 3-Way, key-operated Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
AC Corbin Type Locking Switches,
Model No. AH119x Series
 - 2. LEVITON
www.leviton.com
Heavy Duty AC Toggle Switches,
Key Locking Switches,
Model No. 122x-2KL;
 - 3. City Preapproved Equal
 - F. Momentary contact, 2-circuit, center off, 120/277VAC, 20A; NEMA WD 1 & 6; UL 20; Color to be specified by City;
 - G. Acceptable Momentary contact, 2-circuit, center off Manufacturers;
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
AC Quiet Toggle Switches,
Model No. 122x Series;
 - 2. LEVITON
www.leviton.com
Heavy Duty AC Toggle Switches,
Momentary Contact Switches,
Model No. 1257 Series;
 - 3. City Preapproved Equal
 - H. Spring Wound Interval Timer Switch, 120/277VAC, 20A;
 - I. Acceptable Spring Wound Interval Timer Switch Manufacturers
 - 1. INTERMATIC INC.
www.intermatic.com

- Spring Wound Interval Timer,
Model No. FF60MHC;
1-HP 125VAC, 50/60-Hz;
2-HP 250VAC, 50/60-Hz;
20A 125VAC, 50/60-Hz;
10A 150VAC, 50/60-Hz;
10A 277VAC, 50/60-Hz;
7A 125VAC, Tungsten;
- 2. City Preapproved Equal

2.37 STRAIGHT-BLADE RECEPTACLES

- A. All receptacles shall conform to Federal Specification WS-596; Straight-blade receptacles shall be of the following types:
- B. Single/Duplex Receptacle; 20A, 125VAC, NEMA 5-20R, 1P/2P, 3W, Industrial, Extra Heavy Duty Specification Grade, Straight Blade, Self-Grounding; 10-Year Limited Warranty; Color to be specified by City;
- C. Acceptable Single/Duplex Receptacle Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Premium Industrial Grade Receptacles,
Model No. 536x Series;
 - 2. LEVITON
www.leviton.com
Heavy-Duty Industrial Grade Straight Blade Receptacles,
Model No. 536x Series;
 - 3. City Preapproved Equal
- D. Weatherproof Cover; Single or Duplex Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Vertical Extra Deep Self Closing Lid;
- E. Acceptable Weatherproof Cover; Single or Duplex Receptacle Wall-plate, Rain-tight While-In-Use Manufacturers
 - 1. LEVITON
www.leviton.com
1-Gang Single/Duplex Device Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Horizontal Lid – Gray;
Model No. 5978-GY (Single);
Model No. 5996-GY (Duplex);
 - 2. City Preapproved Equal
- F. Duplex, Corrosion-Resistant Receptacle; 20A, 125VAC, NEMA 5-20R, 2P, 3W, Industrial, Extra Heavy Duty Specification Grade, Straight Blade, Self-Grounding; 10-Year Limited Warranty; Color to be specified by City;
- G. Acceptable Duplex, Corrosion-Resistant Receptacle Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Corrosion Resistant Premium Industrial Grade,
Model No. 5362CR;

- Gray or Yellow;
- 2. LEVITON
www.leviton.com
Heavy-Duty Industrial Grade Straight Blade Receptacles,
Model No. 53CM-62;
Yellow;
- 3. City Preapproved Equal
- H. Ground Fault Circuit Interrupters (GFCI), Duplex, Receptacle; 20A,
125VAC, NEMA 5-20R, 2P, 3W, Industrial, Extra Heavy Duty Specification
Grade, Straight Blade, Self-Grounding; Color to be specified by City;
- I. Acceptable Ground Fault Circuit Interrupters (GFCI), Duplex, Receptacle
Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Weather Resistant GFCI Receptacle,
Model No. WRVGF20;
20A 125VAC, NEMA 5-20R;
 - 2. LEVITON
www.leviton.com
Ground Fault Circuit Interrupters (GFCI),
Model No. W7899-W;
20A, 125VAC, Weather Resistant Smart Lock Pro GFCI,
Monochromatic, wall plate sold separately – White;
2-Year Limited Warranty;
 - 3. HUBBELL® INC.
www.hubbell-wiring.com
Circuit Guard® Heavy Duty Commercial and Hospital Grade GFCI
Receptacle with Auto Grounding,
Catalog No. GF15xx
Utility Outlet in A Control Panel Use Only - 15A, 125VAC;
 - 4. City Preapproved Equal
- J. Stainless Steel Indoor Wall Plate GFCI Duplex Receptacle;
- K. Acceptable Stainless Steel Indoor Wall Plate GFCI Duplex Receptacle
Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Stainless Steel Decorator,
Model No. 93401;
 - 2. LEVITON
www.leviton.com
Decora Wall plates,
Model No. 84401-40;
Decora/GFCI Device Decora Wall plate, Standard Size, 302 Stainless
Steel, Device Mount, - Stainless Steel;
 - 3. City Preapproved Equal
- L. Weatherproof Cover for GFCI Duplex Receptacle;

- M. Acceptable Weatherproof Cover for GFCI Duplex Receptacle Manufacturers
 - 1. LEVITON
www.leviton.com
 1-Gang Single/Duplex Device Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Horizontal Lid – Gray; Model No. 5996-DGY (Duplex);
 - 2. City Preapproved Equal
- N. Single Receptacle; 20A, 250VAC, NEMA 6-20R, 2P, 3W, Industrial; Color to be specified by City;
- O. Acceptable Single Receptacle Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
 ARROW-HART™ Wiring Devices, Isolated Ground Premium Industrial Grade Receptacles, Model No. IG5461; 20A, 250VAC, NEMA 6-20R;
 - 2. LEVITON
www.leviton.com
 Wetguard Devices Receptacles, Model No. 5461; 20A, 250VAC, NEMA 6-20R, 2P, 3W, Narrow Body Single Receptacle, Straight Blade, Industrial Grade, Grounding, Corrosion Resistant, Side Wired, Nickel-Plated Brass Strap, - Yellow; Lifetime Warranty;
 - 3. City Preapproved Equal

2.38 DEVICE PLATES

- A. Plates for flush mounted devices shall be of the required number of gangs for the application involved and shall be 302 (18-8) high nickel stainless steel of the same Manufacturer as the device;
- B. Plates for surface mounted device boxes shall be of the same material as the box;
- C. Acceptable Device Plate Manufacturers
 - 1. COOPER INDUSTRIES
www.arrowhart.com
 302 (18-8) high nickel stainless steel;
 - 2. LEVITON
www.leviton.com
 302 (18-8) high nickel stainless steel;
 - 3. City Preapproved Equal

2.39 RECEPTACLES, RJ-45 MODULAR

- A. Industrial grade;
- B. Acceptable Receptacles, RJ-45 Modular Manufacturers
 - 1. LEVITON
www.leviton.com
 DuraPort™ Industrial Outlet Kits;

2. City Preapproved Equal

2.40 WIRING DUCTS AND COVERS, SLOTTED

- A. Used for organizing, routing and concealing wiring in control panels; Light Gray Color;
- B. Acceptable Wiring Ducts and Covers, Slotted Manufacturers
 - 1. PANDUIT® CORP.
www.panduit.com
PANDUCT® Type G (Wide Finger Flush Design) and PANELMAX™ DIN Rail;
 - 2. THOMAS & BETTS
www.tnb.com
TY-DUCT™ Wide-Slot;
 - 3. City Preapproved Equal

2.41 UNINTERRUPTIBLE POWER SUPPLY (UPS), 5KVA AND LARGER

- A. UL Listed;
- B. Acceptable Uninterruptible Power Supply (UPS), 5kVA and Larger Manufacturers
 - 1. EATON CORPORATION
www.powerware.com
POWERWARE®
w/ SNMP Network Card
 - 2. City Preapproved Equal

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all devices in accordance with the Manufacturer's instructions and the Contract Drawings.
- B. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.
- C. Caulk seams, cracks, and openings in outdoor enclosures.

3.2 ADJUSTING AND CLEANING

- A. The devices described in this section shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.3 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup

- service.
- B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- C. Verify that all devices are installed and connected according to the Contract Documents.
- D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
- E. Verify that wiring installation complies with requirements in Division 16 Sections.
- F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

3.6 INSTALLATION - TRANSFORMERS, DRY TYPE LIGHTING

- A. Set transformers plumb and level.
- B. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by the Manufacturer.
- C. Ensure that transformer are loaded in a reasonably balanced manner across all three phases.
- D. Once the system has been energized, and prior to final commissioning and start-up, measure primary and secondary voltages and adjust the appropriate tap(s);

End of Section

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MISCELLANEOUS EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

- A. Furnish and install all miscellaneous devices and equipment as hereinafter specified and/or as shown on the Contract Drawings.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 2. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 3. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers;
 - 4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 5. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 - 1. Descriptive bulletins;

2. Product data sheets;
3. Master drawing index;
4. Dimensioned front & plan view of the assembly;
5. Schematic diagram;
6. Cable terminal sizes;
7. Component list;
8. Conduit space entry/exit locations;
9. Ratings;
10. Wiring diagrams;
11. Installation information;

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical devices or equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 2. The miscellaneous devices and/or equipment shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer’s instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 BLOCKS, FUSE AND FUSES, 0 TO 600VAC

- A. Current-limiting, with 200,000-ampere Root Mean Square (RMS) interrupting rating; Provide to fit mountings specified with switches and features to reject Class H fuses;
 1. Motor & Transformer Circuits, 0 to 250VDC and 0 to 600VAC - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;

2. Feeder and Service Circuits, 0 to 250VDC and 0 to 600VAC - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
3. Feeder and Service Circuits, 0 to 600VDC – Amperage 601 to 6,000VAC; UL 198C, Class L, double O-rings and silver links;
4. Control circuit specifics;
- B. Acceptable Blocks, Fuse and Fuses, 0 to 600VAC Manufacturers
 1. COOPER BUSSMANN®
www.bussmann.com
 2. LITTELFUSE®
www.littelfuse.com
 3. MERSEN USA
www.mersen.com

2.2 MINI-POWER CENTER

- A. Furnish and install a single-phase and three-phase general purpose individually mounted mini-power centers of the two-winding type, self-cooled, as specified herein and as shown on the Contract Drawings.
- B. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.
- C. Ratings:
 1. kVA and voltage ratings shall be as shown on the Contract Drawings;
 2. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96;
 3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
 - a. Up to 9 kVA 40 db;
 - b. 10 to 30 kVA 45 db;
 - c. 40 to 150kVa 50 db;
- D. Construction:
 1. Each mini-power center shall include a primary main breaker, an encapsulated dry-type transformer and a panelboard with secondary main breaker;
 2. Primary main, secondary main and feeder breakers shall be enclosed with a padlockable hinged door;
 3. Mini-power centers shall be suitable for service entrance application;
 4. Insulation Systems -
 - a. Transformers shall be insulated with a 185 °C insulation system and rated at 115 °C temperature rise;
 - b. Required performance shall be obtained without exceeding the above-indicated temperature rise in a 40 °C maximum ambient, with a 30 °C average over 24-hours;
 - c. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635;
 5. Core and Coil Assemblies -

- a. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction;
 - b. The core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level;
 - c. The core of the transformer shall be grounded to the enclosure;
 - d. Provide two (2) 5% FCBN taps;
- E. Bus:
 - 1. Secondary bus shall be copper.
- F. Wiring/Terminations
 - 1. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer and distribution section shall be factory installed;
 - 2. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring;
- G. Main Breakers
 - 1. Each mini-power center shall include a primary main breaker with an interrupting rating of 14 kA at 277/480 volts; and a secondary main breaker with an interrupting rating of 10kA at 120/240 volts, and a panelboard;
- H. Feeder Breakers
 - 1. The secondary distribution section shall use ONLY bolt-on breakers with 10 kA interrupting capacity;
- I. Enclosure
 - 1. The enclosure shall be made of heavy-gauge steel and the maximum temperature of the enclosure shall not exceed 90 °C;
 - 2. The enclosure shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes;
- J. Acceptable Mini-Power Center Manufacturers
 - 1. EATON CORPORATION
www.eaton.com
 See Section 16160 Panelboard and 16050 Basic Electrical Materials and Methods for specific product offerings;
 - 2. SIEMENS INDUSTRY
www.automation.siemens.com
 See Section 16160 Panelboard and 16050 Basic Electrical Materials and Methods for specific product offerings;
 - 3. **SQUARE D – Mini Power Zone**

2.3 SWITCHES, SINGLE-THROW FUSED, 0 TO 600VAC

- A. Stainless Steel (Internal & External); UL Listed; NEMA Standards

Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600VAC Maximum); Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions; Suitable for use with 75 °C wire at full NFPA® 70, 75 °C ampacity; Enclosure: NEMA 4X 316 Stainless Steel; Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position; Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

B. Acceptable Switches, Single-Throw Fused, 0 to 600VAC Manufacturers

1. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Fused,
Part No. DHxxxFWK316;

2. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Fused,
Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).

3. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Fused,
Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).

4. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Fused,
Part No. HFxxxSS;

5. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Fused,
Part No. HFxxxSS; SPD installed,
1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).

6. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Fused,
Part No. HFxxxSS; SPD installed,
1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).

7. **SQUARE D – Single Throw - Fused**

2.4 **SWITCHES, SINGLE-THROW NON-FUSED, 0 TO 600VAC**

- A. Typically used as a means to manually connect or disconnect the load from the source; Stainless Steel (Internal & External) - UL Listed; NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600VAC Maximum); Quick-make, quick-break, visible

blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions; Suitable for use with 75 °C wire at full NFPA 70, 75 °C ampacity; Enclosure: NEMA 4X 316 Stainless Steel; Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position; Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

B. Acceptable Switches, Single-Throw Non-fused, 0 to 600VAC Manufacturers

1. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Unfused,
Part No. DHxxxUWK316;

2. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Unfused,
Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).

3. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER® Unfused,
Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).

4. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Unfused,
Part No. HNFxxxSS;

5. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).

6. SIEMENS INDUSTRY

www.automation.siemens.com

Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).

7. **SQUARE D – Single Throw – Non-fused**

2.5 **TRANSFORMERS, DRY TYPE LIGHTING**

A. 480VAC, 3-phase Primary and

1. UL 1561, NEMA ST 20;

2. Self-cooled, two-winding, UL K-4 rated for nonlinear loads;

3. Insulation Class and Temperature Rise: Manufacturer's standard;

4. Core and Coil –

- a. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA;

- b. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above;
 - c. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated;
 - d. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated;
 - e. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated;
 - f. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated;
 - g. Outdoor Transformers: NEMA 250, Type 3R;
 - h. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - i. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - j. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - k. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
 - l. 40 decibels for 0 to 9 kVA;
 - m. 45 decibels for 10 to 50 kVA;
 - n. 50 decibels for 51 to 150 kVA;
 - o. 55 decibels for 151 to 300 kVA;
 - p. 60 decibels for 301 to 500 kVA;
 - q. Rated for transformer's weight;
 - r. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer;
 - s. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators;
 - t. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator:
- B. Acceptable Transformers, Dry Type Lighting Manufacturers
- 1. EATON CORPORATION
www.eaton.com
NEMA Premium® Efficient Transformers;
 - 2. SIEMENS INDUSTRY
www.sea.siemens.com
NEMA Premium® Efficient Transformers;
 - 3. **SQUARE D – NEMA Premium Efficiency Transformers**

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all devices in accordance with the Manufacturer's instructions and the Contract Drawings.
- B. Remove temporary lifting angles, lugs, and shipping braces. Touch-up damaged paint finishes.
- C. Caulk seams, cracks, and openings in outdoor enclosures.

3.2 ADJUSTING AND CLEANING

- A. The devices described in this section shall be adjusted accordingly per

- Manufacturer's recommendations.
 - B. Clean exposed surfaces using Manufacturer recommended materials and methods.
 - C. Vacuum all interior spaces.
- 3.3 TESTING
- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.
- 3.4 STARTUP SERVICES
- A. Engage a factory-authorized service representative to perform startup service.
 - B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
 - C. Verify that all devices are installed and connected according to the Contract Documents.
 - D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
 - E. Verify that wiring installation complies with requirements in Division 16 Sections.
 - F. Complete installation and startup checks according to Manufacturer's written instructions.
- 3.5 WARRANTY (PURCHASE ONLY)
- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.
- 3.6 WARRANTY (PROJECT)
- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

RACEWAYS, BOXES AND FITTINGS

PART 1 - GENERAL

1.1 SCOPE

- A. The CONTACTOR shall furnish and install complete raceway systems as shown on the Contract Drawings and as specified herein.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
- C. Applications
 - 1. Except where otherwise shown on the Contract Drawings, the following describes the conduit requirements for the project:
 - a. All exposed power and control raceways shall be in Rigid Aluminum conduit unless otherwise noted below;
 - b. Underground power conductors shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
 - c. All exposed 4-20mA Instrumentation signals shall be installed in Rigid Aluminum conduit;
 - d. All fiber-optic cable shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
 - e. Underground 4-20mA Instrumentation signals shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
 - f. Conduit sleeves shall be Rigid Non-metallic (PVC) Schedule 80;
 - g. VFD motor conductors shall be installed in Rigid Galvanized Steel PVC Coated (GRS) Conduit;
 - 2. Wherever Rigid Non-metallic (PVC) Schedule 80 is used, all below grade elbows and risers to above grade shall be Rigid Galvanized Steel PVC Coated Conduit (GRS). All elbows above grade shall be suitably grounded. Conduit spaces shall be provided for underground conduit installation.
 - 3. All conduit of a given type shall be the product of one Manufacturer.
 - 4. All switch, outlet and control station boxes and fittings shall be cast aluminum FS boxes with aluminum covers;
 - 5. Concealed switch, outlet and control station boxes in NEMA 1 areas shall be aluminum;
 - 6. All terminal boxes, junction boxes, pull boxes installed outdoors shall be NEMA 4X 316 stainless steel.

7. All boxes installed indoors (except in corrosive areas) may be aluminum.
8. Boxes in corrosive areas shall be PVC; Boxes in lift stations shall be fiberglass.
9. Combination expansion-deflection fittings shall be used where exposed or embedded conduits cross structure expansion joints;
10. Maximum conduit pull box spacing shall not exceed 200', two 90° conduit bends and/or maximum pull tension of material(s) not exceeded;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 1. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
 2. ANSI/UL 651A - Type EB and A Rigid PVC Conduit and HDPE Conduit;
 3. ANSI C80.1 - Electrical Rigid Steel Conduit (ERSC);
 4. ANSI C80.5 - Electrical Rigid Aluminum Conduit (ERAC)
 5. ANSI/ American Society of Mechanical Engineers (ASME) B1.20.1 - Pipe Threads, General Purpose (Inch);
 6. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 7. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 8. NECA 101 - Standard for Installing Steel Conduit (Rigid, IMC, EMT);
 9. NECA 102 - Standard for Installing Aluminum Rigid Metal Conduit;
 10. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC);
 11. National Electrical Manufacturers Association (NEMA) TC-2 - Electrical Polyvinyl Chloride (PVC) Conduit;
 12. National Fire Protection Association® (NFPA®) 70 - National Electric Code® (NEC®);
 13. NEC® Article 344 - Rigid Metal Conduit: Type RMC;
 14. NEC® Article 350 - Liquidtight Flexible Metal Conduit: Type LFMC;
 15. NEC® Article 352 - Rigid Polyvinyl Chloride Conduit: Type PVC;
 16. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;
 17. NFPA® 70E® - Electrical Safety in the Workplace;
 18. Underwriters Laboratories (UL) 5A - Surface Nonmetallic Raceways;
 19. UL 6 - Electrical Rigid Metal Conduit - Steel;
 20. UL 6A - Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel;
 21. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;

22. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
23. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances;
24. UL 360 - Liquid-Tight Flexible Steel Conduit;
25. UL 514A - Metallic Outlet Boxes;
26. UL 514B - Conduit, Tubing, and Cable Fittings;
27. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Master drawing index;
 4. Dimensioned front & plan view of the assembly;
 5. Schematic diagram;
 6. Cable terminal sizes;
 7. Component list;
 8. Wiring diagrams;
 9. Installation information;
- E. Submit product data for the following:
 1. Surface raceway and fittings;
 2. Wireway and fittings;
 3. Conduit and fittings for each type specified;
 4. Boxes and cabinets;

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 2. The Raceways, Boxes & Fittings shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on

Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

- D. Contractor shall comply with all NEMA standards pertaining to raceways.
- E. Contractor shall comply with requirements of all UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 RIGID STEEL METAL CONDUIT (RSC) AND FITTINGS

- A. Material shall meet or exceed the following:
 - 1. Use under the provisions of NEC® Article 344 - Rigid Metal Conduit: Type RMC;
 - 2. American National Standards Institute (ANSI) C80.1 - Electrical Rigid Steel Conduit (ERSC);
 - 3. Rigid steel conduit interior and exterior shall be hot-dipped galvanized;
 - 4. Minimum ¾-inch conduit shall be specified or used;
- B. Fittings
 - 1. Locknuts: Steel or malleable iron;
 - 2. Bushings: Threaded type, steel or malleable iron, with 221 °F (105 °C) rated plastic insulated throat. Plastic bushings with a rating of 221 °F (105 °C) may be used for conduits 1-inch and smaller.
 - 3. Box connectors for damp and wet locations: Provide a watertight threaded hub on enclosure consisting of sealing fitting with tapered conduit thread, neoprene O-ring, and 221 °F (105 °C) rated insulating throat with grounding and bonding lug.
 - 4. Couplings: Threaded, hot dipped galvanized after fabrication.
- C. Long Radius Elbows (90 degrees)
- D.

Conduit Size (inches)	Minimum Radius (inches)
¾	12
1	12
1-½	12
2	15
2- ½	15

3	18
3-½	18
4	30
5	36
6	42

E. Acceptable RSC and Fittings Manufacturers

1. ATKORE INTERNATIONAL
www.atkore.com
ALLIED TUBE & CONDUIT
Steel Rigid Conduit;
2. REPUBLIC CONDUIT™
www.republic-conduit.com
Galvite® Electrical Rigid Metal Conduit-Steel;
3. WESTERN TUBE & CONDUIT CORPORATION
www.westerntube.com
Rigid Steel Conduit;
4. WHEATLAND TUBE COMPANY
www.wheatland.com
Rigid Steel Conduit;

2.2 PVC COATED GALVANIZED RIGID STEEL CONDUIT (GRS) AND FITTINGS

- A. Material shall meet or exceed the following:
 1. Urethane coating on threads;
 2. Minimum 40 mil PVC permanently bonded coating on exterior;
 3. Minimum 2 mil urethane coating on interior;
- B. Acceptable PVC GRS and Fittings Manufacturers
 1. CALCONDUIT™
www.calconduit.com
UL Listed PVC Coated Conduit;
 2. PERMA-COTE COATED CONDUIT
www.permacote.com
Perma-Cote Coated Conduit & Fittings;
Plasti-Bond Coated Galvanized Rigid Conduit & Fittings;
KorKap® PVC Rigid Metal Conduit & Fittings;
 3. THOMAS & BETTS
www.tnb.com
Ocal® PVC Coated Conduit & Fittings;

2.3 RIGID ALUMINUM METAL CONDUIT (RAC) AND FITTINGS

- A. Material shall meet or exceed the following:
 1. Use under the provisions of NEC® Article 344 - Rigid Metal Conduit: Type RMC;
 1. American National Standards Institute (ANSI) C80.5 – Electrical Rigid Aluminum Conduit (ERAC)
 2. Underwriters Laboratories (UL) 6A - Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel;
 3. Minimum ¾-inch conduit shall be specified and used;

B. Acceptable RAC and Fittings Manufacturers

1. ATKORE INTERNATIONAL
www.atkore.com
ALLIED TUBE & CONDUIT
Aluminum Rigid Conduit;
2. REPUBLIC CONDUIT™
www.republic-conduit.com
Aluminum Rigid Conduit;
3. WHEATLAND TUBE COMPANY
www.wheatland.com
Aluminum Rigid Conduit;

2.4 RIGID ALUMINUM BUSHING

- A. Material
- B. Acceptable Rigid Aluminum Bushing Manufacturers
 1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type AB - Insulated
Type ABLG - Grounding
 2. City Preapproved Equal

2.5 RIGID ALUMINUM CABLE SEALING FITTING

- A. Material
- B. Acceptable Rigid Aluminum Cable Sealing Fitting Manufacturers
 1. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
Type CG-S
 2. City Preapproved Equal

2.6 RIGID ALUMINUM CONDUIT SEALING FITTING

- A. Material
- B. Acceptable Rigid Aluminum Conduit Sealing Fitting Manufacturers
 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type EYSR
 2. City Preapproved Equal

2.7 RIGID ALUMINUM DRAIN SEAL

- A. Material
- B. Acceptable Rigid Aluminum Drain Seal Manufacturers
 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type EYD-SA or Type EZD-SA
 2. EGS ELECTRICAL GROUP

www.appletonelec.com

APPLETON®

Type EYDM-A

3. City Preapproved Equal

2.8 RIGID ALUMINUM DRAIN/BREATHING FITTING

A. Material

B. Acceptable Rigid Aluminum Drain/Breathing Fitting Manufacturers

1. COOPER INDUSTRIES

www.crouse-hinds.com

CROUSE-HINDS®

Type ECD

2. EGS ELECTRICAL GROUP

www.appletonelec.com

APPLETON®

Type DB

3. City Preapproved Equal

2.9 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Material shall meet or exceed the following:

1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
3. NEMA TC-2 - Electrical Polyvinyl Chloride (PVC) Conduit;
4. Minimum 1-inch conduit shall be specified and used;

B. Acceptable PVC and Fittings Manufacturers

1. ATKORE INTERNATIONAL

www.atkore.com

ALLIED TUBE & CONDUIT

UL Listed Rigid Schedule-40 & Schedule-80 PVC Electrical Conduit

2. CANTEX®

www.cantexinc.com

UL Listed Schedule-40 or 80 PVC Electrical Conduit;

3. THOMAS & BETTS

www.carlon.com

CARLON®

Carlon Plus 40® and Plus 80® Rigid PVC Conduit;

4. City Preapproved Equal

2.10 RIGID NON-METALLIC CONDUIT (PVC) TYPE DIRECT BURIAL (DB) CONDUIT AND FITTINGS

A. Material shall meet or exceed the following:

1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;

2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
3. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;
- B. Acceptable DB PVC and Fittings Manufacturers
 1. CANTEX®
www.cantexinc.com
Utility Duct DB60 and DB120;
 2. THOMAS & BETTS
www.carlon.com
CARLON®
P&C® Duct DB60 and DB120;
 3. City Preapproved Equal

2.11 RIGID NON-METALLIC (PVC) CONDUIT TYPE ENCASED BURIAL (EB) CONDUIT AND FITTINGS

- A. Material shall meet or exceed the following:
 1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
 2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
 3. ANSI/UL 651A - Type EB and A Rigid PVC Conduit and HDPE Conduit;
 4. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;
- B. Acceptable EB PVC and Fittings Manufacturers
 1. CANTEX®
www.cantexinc.com
Utility Duct EB20 and EB35;
 2. THOMAS & BETTS
www.carlon.com
CARLON®
P&C® Duct EB20 and EB35;
 3. City Preapproved Equal

2.12 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Material
 1. Use under the provisions of NEC® Article 350 – Liquidtight Flexible Metal Conduit: Type LFMC;
 2. Underwriters Laboratories (UL) 360 - Liquid-Tight Flexible Steel Conduit;
 3. Hot Dipped Zinc Galvanized Steel Core with Bonding Wire;
 4. Polyvinyl Chloride (PVC) Cover;
 5. Gray Color;
 6. -4 °F to +140 °F (-20 °C to +60 °C) Temperature Range;
- B. Acceptable LFMC Manufacturers

1. AFC CABLE SYSTEMS®, INC.
www.afcweb.com
LIQUID-TUFF™
UL Liquidtight Flexible Steel Conduit, Type LFMC;
2. ANAMET ELECTRICAL, INC.
www.anacondasealtite.com
Anaconda Sealtite®
Flexible Conduit, Product Type UA – UL Listed;
3. City Preapproved Equal

2.13 LIQUIDTIGHT FLEXIBLE METAL (LFMC) FITTINGS

- A. Material shall meet or exceed the following:
 1. Use under the provisions of NEC® Article 350 – Liquidtight Flexible Metal Conduit: Type LFMC;
 2. Underwriters Laboratories (UL) 514B - Fittings for Cable and Conduit;
 3. ANSI/NEMA FB-1;
 4. Heavy-duty, impact resistant construction;
 5. Factory installed “O” ring seals against lubricants and other liquids;
 6. All malleable iron construction;
 7. Full-size UL locknut;
 8. Threaded locking mechanism;
 9. Outer bushing conforms to nut and conduit;
- B. Acceptable LFMC Fittings Manufacturers
 1. AFC CABLE SYSTEMS®, INC.
www.afcweb.com
Malleable Iron Liquidtight Insulated Fittings;
 2. THOMAS & BETTS
www.tnb.com
Malleable Iron Liquidtight Insulated Fittings;
 3. City Preapproved Equal

2.14 CONDUIT BODIES

- A. Applications - Serve as pulling fittings; Make bends in conduit system; Provide openings for splicing; Connect and change direction of conduit runs; Allow connections for branch runs; Permit access to conductors for maintenance. Among the types are:
 1. L-shaped bodies ("Ells") include the LB, LL, and LR, where the inlet is in line with the access cover and the outlet is on the back, left and right, respectively. In addition to providing access to wires for pulling, "L" fittings allow a 90° turn in conduit where there is insufficient space for a full-radius 90° sweep (curved conduit section).
 2. T-shaped bodies ("Tees") feature an inlet in line with the access cover and outlets to both the cover's left and right.
 3. C-shaped bodies ("Cees") have identical openings above and below the access cover and are used to pull conductors in straight runs as they make no turn between inlet and outlet.

4. Service "Ells" (SLBs), shorter with inlets flush with the access cover, are frequently used where a circuit passes through an exterior wall from outside to inside.
5. Mogul bodies are used for large and heavy conductor pulls;
- B. Rigid Steel, Rigid Aluminum Conduit Bodies (Non-hazardous)
 1. National Electrical Manufacturers Association (NEMA) FB-1 - Fittings, Cast Metal Boxes, And Conduit Bodies for Conduit, Electrical Metallic Tubing, And Cable;
 2. Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
 3. UL 514A - Metallic Outlet Boxes;
 4. UL 514B - Conduit, Tubing, and Cable Fittings;
- C. Acceptable Rigid Steel, Rigid Aluminum Conduit Bodies (Non-hazardous) Manufacturers
 1. COOPER INDUSTRIES
www.crouse-hinds.com
 CROUSE-HINDS®
 Condulet® Form 7™ Conduit Bodies;
 Use Cast Iron Bodies & Sheet Steel Wedge nut w/Integral Gasket for Rigid Steel Installations;
 Use Aluminum Bodies & Sheet Aluminum Wedge nut w/Integral Gasket for Rigid Aluminum Installations;
 2. EGS ELECTRICAL GROUP
www.appletonelec.com
 APPLETON®
 FM7™ Unilet® Conduit Outlet Bodies;
 Use Grayloy-iron Bodies & Steel Wedge-Lok™ Stamped Covers for Rigid Steel Installations;
 Use Copper free aluminum Bodies and Aluminum Wedge-Lok™ Stamped Covers for Rigid Aluminum Installations;
 3. HUBBELL® INC.
www.hubbell.com
www.hubbell-killark.com
 KILLARK® Series O,
 Type E Electrolets
 4. City Preapproved Equal
- D. Rigid Non-Metallic (PVC) Conduit Bodies (Non-hazardous)
 1. NEMA OS-2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports;
 2. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers;
- E. Acceptable Rigid Non-Metallic (PVC) Conduit Bodies (Non-hazardous) Manufacturers
 1. CANTEX®
www.cantexinc.com
 (PVC) Conduit Bodies;
 2. THOMAS & BETTS
www.carlon.com
 CARLON®

1. Box: cast copper-free aluminum;
 2. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws;
 3. Hubs: Threaded;
 4. Lugs: Cast Mounting;
- E. Acceptable Cast Aluminum (Non-hazardous) Manufacturers
1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type FS-SA or FD-SA;
 2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON® or
O-Z/GEDNEY
Type FS or FD;
 3. City Preapproved Equal
- F. Aluminum (Hazardous)
- G. Acceptable Aluminum (Hazardous) Manufacturers
1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Condulet® Series Explosion-proof Outlet Boxes
 2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
OE Conduit Outlet Boxes
 3. City Preapproved Equal
- H. Metal/Aluminum DIN Mountable (Non-hazardous)
1. DIN mount Surge Protected Dual Outlet for 120VAC, 15A Service;
- I. Acceptable Metal/Aluminum DIN Mountable (Non-hazardous) Manufacturers
1. HUBBELL® INC.
www.hubbell-wiring.com
DIN Rail Utility Box,
Part No. DRUBTVSS15;
 2. PHOENIX CONTACT
www.phoenixcon.com
EM-DUO-120/15/SPD
Part No. 56 01 28 3;
 3. City Preapproved Equal
- J. Non-Metallic
1. Box: PVC;
 2. Cover: PVC, weatherproof, with stainless steel screws;
- K. Acceptable Non-Metallic Manufacturers
1. CANTEX®
www.cantexinc.com
Type FS or FS
With Weatherproof covers;

2. THOMAS & BETTS
CARLON®
www.carlon.com
Type FS or FD
with Type E98 or E96 covers;
3. City Preapproved Equal

2.16 BOXES, JUNCTION AND PULL

- A. Aboveground Material
 1. Stainless Steel – NEMA 4X;
 2. Type 316 stainless steel (Continuous-hinge with clamps (bolted or screwed) covers with gaskets;
 3. If used for a terminal junction box, provide terminal strips or terminal blocks with a separate connection point for each conductor entering or leaving the box. Also, provide a minimum of 25% spare terminal points);
 4. ALL NEMA 4X Large (≥24-inch Height x 20-inch Wide) Wall-Mount shall have continuous-hinge with 3-Point Latch;
- B. Acceptable Aboveground Boxes, Junction and Pull Manufacturers
 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
HOFFMAN® Stainless Steel Continuous Hinge Type 4X CHNFSS Junction Boxes
Continuous Hinge with 3-Point Latch, Type 4X SSLP3PT Enclosures
 2. RITTAL CORP.
www.rittal.com
NEMA 4X Junction Boxes;
 3. City Preapproved Equal
- C. Underground Material (i.e. Pull Box, Junction Box, Hand Hole, Splice Box)
 1. Fiberglass/Polymer Concrete;
 2. Lightweight;
 3. Designed for Tier 8 (12,000lbs) applications;
 4. Flared design;
 5. Minimum 18" Depth;
 6. Bolted Cover;
 7. Cover Marking – as required (i.e. ELECTRIC, CONTROL, FIBER);
- D. Acceptable Underground Boxes, Junction and Pull Manufacturers
 1. HIGHLINE PRODUCTS
www.highlineproducts.com
Composite Hand hole Assembly
CHA Series;
 2. HUBBELL® POWER SYSTEMS
www.hubbellpowersystems.com
QUAZITE® Below Ground Flared CDR Style;
 3. City Preapproved Equal

2.17 RIGID METAL CONDUIT FITTINGS

- A. Acceptable Rigid Metal Conduit Fittings Manufacturers

1. ARLINGTON INDUSTRIES
www.aifittings.com
Locknuts, Plastic Insulating Bushings
2. THOMAS & BETTS
www.tnb.com
Locknuts, Sealing Locknuts, Bonding Locknuts, Threaded Insulated
Grounding Bushings
3. City Preapproved Equal

2.18 RIGID ALUMINUM EXPANSION FITTING

- A. Acceptable Rigid Aluminum Expansion Fitting Manufacturers
 1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
XD Series Expansion/Deflection Couplings;
 2. THOMAS & BETTS
www.tnb.com
T&B® XD Series
Expansion/Deflection Couplings;
 3. City Preapproved Equal

2.19 CONDUIT SEALS

- A. For Sealing Around Conduit Passing through a Wall or Floor;
- B. Acceptable Conduit Seals Manufacturers
 1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type WSK;
 2. City Preapproved Equal

2.20 CONDUIT SEALING BUSHINGS

- A. For Use with Insulated Wire, Cable and Rigid Metal Conduit; Sealing
Bushings are used to seal against fluid and gas pressure around
mechanical pipes, casing, conduits or tubes.
- B. Acceptable Conduit Sealing Bushings Manufacturers
 1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSB or CSM Series;
 2. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSM Series CSML;
 3. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSM Series CSML;
 4. City Preapproved Equal

2.21 CONDUIT MOUNTING HARDWARE

- A. Reference Section 16190 - Supporting Devices.
 - 1. REFERENCE
SECTION 16190
SUPPORTING DEVICES
 - 2. NO EQUAL

2.22 CONDUIT & FITTINGS CORROSION PROTECTIVE COATINGS

- A. Acceptable Conduit & Fittings Corrosion Protective Coatings Manufacturers
 - 1. THOMAS & BETTS
www.tnb.com
Kopr-Shield® Compound
 - 2. CARBOLINE® COMPANY
www.carboline.com
Carbomastic®
 - 3. PORTER PAINT CO.
www.porterpaints.com
PorterTuf™ 2000 HB Coal Tar Epoxy
 - 4. City Preapproved Equal

2.23 GALVANIZING REPAIR STICK

- A. A galvanizing repair stick shall be heated and applied like a crayon to repair nicks and scratches on conduit; It offers superior protection of ferrous metals and bond to both iron or steel;
- B. Acceptable Galvanizing Repair Stick Manufacturers
 - 1. ROTOMETALS, INC.
www.rotometals.com
"REGALV" Galvanizing Repair Stick-Lead Free;
 - 2. City Preapproved Equal

2.24 ANTI-SEIZE/ANTI-CORROSION (COPPER) COMPOUND

- A. Copper anti-seize, anti-corrosion compound shall be applied to the threads of all bolts & screws prior to installation.
- B. The anti-seize, anti-corrosion compound shall be appropriate to the hardware material being assembled.
- C. Use on all types of threaded connections, bushings, keyways, press fits, etc. to protect against seizure, heat freeze, galling, rust and corrosion.
- D. Acceptable Anti-Seize/Anti-Corrosion (Copper) Compound Manufacturers
 - 1. CRC® INDUSTRIES, INC.
www.crcindustries.com
Sta-Lube Copper Anti-Seize;
 - 2. HENKEL CORPORATION
www.loctite.com
LOCTITE® C5-A®;
 - 3. JET LUBE®
www.jetlube.com
KOPR-KOTE®;
 - 4. PERMATEX®, A Division of ITW

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Conduit Usage Schedule: Install the following types of conduits and fittings in locations listed, unless otherwise noted in the Contract Drawings. Definitions and requirements of NEC® apply unless specifically modified below.
1. Exterior and interior, exposed:
 - a. Material: Rigid Aluminum Conduit except PVC Schedule 80 for armored cables;
 - b. Minimum size: 1 -inch;
 2. Everywhere else:
 - a. Material: PVC Schedule 80;
 - b. Minimum size: 1-inch;
 3. Embedded in Concrete:
 - a. Material: Rigid Aluminum Conduit or PVC Type EB;
 - b. Minimum size: 1-inch;
 4. In earth below concrete slabs:
 - a. Material: PVC Schedule 40. Rigid steel ells for bends exceeding 45°;
 - b. Minimum size: 1-inch;
 5. Conduit stub-ups: Rigid Galvanized Steel PVC Coated Conduit (GRS) long radius ells for stub-ups that connect to underground rigid PVC conduit.
 6. Final Connections to transformers, vibrating equipment or instruments:
 - a. Material: Schedule 80 flexible PVC.
 - b. Minimum size: 1-inch;
- B. General Conduit Installation
1. No conduit smaller than 1-inch electrical trade size shall be used;
 2. No more than three (3) 90° bends in any one run shall be used;
 3. Conduit runs are shown schematically on the Contract Drawings;
 4. Pull boxes, junction boxes, and other ancillary equipment are not usually shown on the Contract Drawings. The Contractor shall provide as specified in this specification and required by NEC®;
 5. Conduits, fittings and junction boxes for lighting, receptacles and outlets are not shown for clarity. Provide as required by NEC®. Provide additional pull boxes and junction boxes to permit pulling of wires without damage to the conductors or insulation.
 6. Minimum size in floor slabs shall be 1-inch;
 7. No conductor shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail;

8. Reference Section 16110-2.23. Anti-Seize/Anti-Corrosion (Copper) Compound;
9. Cap all conduits with Manufacturer-approved caps immediately after installation to prevent entrance of foreign matter.
10. Conduit supports shall be spaced at intervals as required to obtain rigid construction, but in no case less than as required by the NEC®;
11. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates to raise conduits from the surface. Reference 16110-2.21. Conduit Mounting Hardware;
12. Multiple runs of conduits shall be supported on trapeze type hangers with horizontal members and threaded hanger rods. The rods shall not be less than 3/8-inch diameter. Reference 16110-2.21. Conduit Mounting Hardware;
13. Conduit hangers shall be attached to structural steel by means of beam or channel clamps; Where attached to concrete surfaces, concrete inserts of the spot type shall be provided;
14. All conduits of exposed work shall be run at right angles to and parallel and perpendicular to surface or exposed structural members and follow surface contours as much as practical to provide a neat appearance; No diagonal runs will be allowed; Bends in parallel conduit runs shall be concentric; all conduits shall be run perfectly straight and true; Conduits not installed in this fashion shall be replaced entirely at the Contractor's expense with no cost to the City.
15. Make right angle bends in conduit runs with long radius elbows or conduits bent to radii not less than those of specified for long radius ells.
16. No unbroken conduit runs shall exceed 200-feet in length. This length shall be reduced by 75-feet for each 90° elbow;
17. The location of all junction boxes must be approved by the Engineer and City before installation;
18. Conduit Terminations:
 - a. Terminate all conduits with locknuts and grounding bushings; Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings installed; Conduit terminating in gasketed enclosures shall be terminated with conduit hubs;
 - b. Install conduits squarely to the box and provide one locknut outside the box and one locknut and grounding bushing inside the box.
 - c. Install locknuts with dished side against the box.
 - d. When terminating in threaded hubs, screw the conduit or fitting tight into the hub so that the end bears against the wire protection shoulder.
 - e. When chase nipples are used, install the raceway and coupling square to the box and tighten the chase nipple leaving no exposed threads.
 - f. Metallic conduit entering manholes and below grade pull boxes shall be terminated with grounding type bushings and connected

- together to a $\frac{3}{4}$ -inch x 20-foot ground rod with a minimum #6 bare copper wire or larger per NEC®;
19. Conduit wall seals shall be used for all conduits penetrating walls below grade or other locations shown on the Contract Drawings;
 20. Provide expansion fittings for raceways crossing expansion joints in structures and in straight runs exceeding 100-feet and as shown in NEC®;
 21. The distance between pull boxes shall not exceed 200 feet;
 22. Explosion-proof flexible couplings shall be used in all hazardous locations;
 23. Conduit stub outs for future construction shall be provided with threaded PVC end caps at each end;
 24. Underground 120VAC circuits (Schedule 80 PVC) shall be installed directly to the respective lighting panel;
 25. Stainless steel pull boxes shall be wall-mounted on structures to eliminate excessive bends;
 26. A formed, 3- $\frac{1}{2}$ -inch high, with 3-inch minimum on each side, concrete conduit housekeeping pad shall be required for all exposed conduit stub-ups; This applies to ALL exposed conduits installed indoors or outdoors;
 27. Always install and leave a nylon pull string in all conduits for future pulls;
- C. Rigid Nonmetallic (PVC) Conduit Requirements
1. Comply with the installation provisions of NEMA Standard TC2, except as modified below.
 2. Make cuts with a fine tooth handsaw. For sizes two-inches and larger, use a miter box or similar saw guide to assure a square cut.
 3. Use factory made couplings for joining conduit.
 4. Any PVC Conduit bends greater than 22 $\frac{1}{2}$ -degrees, install factory-manufactured PVC Coated Galvanized Rigid Steel Conduit (GRS) elbows with approved changeover coupling.
 5. Cementing and joining operation shall not exceed 20-seconds. Do not disturb joint for five-minutes, longer (up to 10-minutes) at lower temperatures. Make joints watertight. Joining procedure shall conform to the detailed procedures of ASTM D-2855.
 6. Install expansion fittings. Expansion fittings are required when the conduit is left exposed in trenches for a period of time during which the conduit's temperature can vary more than 36 °F (2 °C). Install expansion fittings near the fixed end of the run and 100-feet on center.
 7. Install runs of multiple conduits with spacers, of type recommended by the Manufacturer, placed 3 feet on centers.
 8. Provide expansion joints as shown in Article 352 of NEC®.
- D. Liquidtight Flexible Metal Conduit Requirements
1. All Liquidtight flexible metal conduits with separate dedicated grounding conductor shall be used for all motor terminations and other equipment where vibration is present;
- E. Conduit Sealing
1. Seal conduit entries with silicone sealant as follows:

- a. When located out-doors, in damp or wet locations, in areas with corrosive atmosphere, or when the enclosure is indicated as weatherproof.
 - b. At entrance to equipment enclosures.
- 2. The City shall witness the installation of all sealant;
- F. Grounding
 - 1. Install a separate equipment-grounding conductor in all conduits (power, telephone, communication, Fire Alarm, Public Address, paging, sound, CATV, instrumentation and control.)
 - 2. Use grounding bushings for all conduits;
 - 3. Provide a grounding conductor in flexible conduit, size conforming to NEC® Article 250 - Equipment Grounding Conductors.
- G. Damaged Conduit
 - 1. Repair or replace conduit damaged during or after installation.
 - 2. Replace crushed or clogged conduit or any conduit whose inner surface is damaged or not smooth.
 - 3. Repair cuts, nicks, or abrasions in the zinc coating of galvanized conduit with galvanizing repair stick;
- H. Empty Conduit
 - 1. Provide 200-pound strength nylon pull cord in all empty conduits.
 - 2. Provide a waterproof label on each end of the pull cords to indicate the destination of the other end.
- I. Pull Boxes
 - 1. Support wall-mounted pull boxes and panels with Type 316 stainless steel preformed channels and Type 316 stainless steel concrete anchors.

3.2 ADJUSTING AND CLEANING

- A. Upon completion of the installation of raceways and boxes, the Contractor shall inspect interiors of raceways and boxes and adjust accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Clean with wire brush 1 size larger than conduit and mandrel with 1 size smaller than mandrel.
- D. Vacuum all interior spaces.

3.3 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

- A. Verify that all devices are installed and connected according to the Contract Documents.
- B. Verify that raceway installation complies with requirements in Division 16 Sections.

3.5 WARRANTY

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16120

WIRES AND CABLES – 600-VOLT AND LESS

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes materials, installation and testing of wires and cables operating at 600VAC and lower, which are used for distribution of power, non-power-limited control circuits and industrial communications.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
- C. Furnish, install and test all wire, cable and appurtenances as shown on the Contract Drawings, in accordance with the Manufacturer's recommendations and as hereinafter specified.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. American Society for Testing and Materials (ASTM) B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;
 - 2. ASTM B-33 - Tinned Soft or Annealed Copper Wire;
 - 3. American National Standards Institute (ANSI)/ National Electrical Manufacturers Association (NEMA) WC 70-2009/Insulated Cable Engineers Association (ICEA) S-95-658-2009 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy;
 - 4. ANSI/Underwriters Laboratories (UL) 44 - Thermoset-Insulated Wires and Cables;
 - 5. ANSI/UL 62 - Flexible Cords and Cables;
 - 6. ANSI/UL 66 - Fixture Wire;
 - 7. ANSI/UL 83 - Thermoplastic-Insulated Wires and Cables;
 - 8. ANSI/UL 493 - Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables;
 - 9. ANSI/UL 854 - Service-Entrance Cables;
 - 10. ANSI/UL 1581 - Safety for Electrical Wires, Cables, and Flexible Cords;
 - 11. ICEA T-29-520 - Vertical Cable Tray Flame Tests @ 210,000 BTU;
 - 12. Institute of Electrical and Electronics Engineers (IEEE) 323-1974 - Qualifying Class 1E Equipment for Nuclear Power Generating Stations;

13. IEEE 383-1974 – Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations;
14. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
15. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
16. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
17. NFPA® 70E® - Electrical Safety in the Workplace;
18. NFPA® 79 - Electrical Standard for Industrial Machinery;
19. UL 486A-486B – Wire Connectors;
20. UL 1063 - Machine-Tool Wires and Cables;
21. UL 2556 - Wire and Cable Test Methods;
22. UL VW-1 - Vertical-Wire Flame Test;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. Contractor shall submit Manufacturer's sample and data for each conductor and cable type to be used on the project for Engineer's and City's approval. Each sample shall have the size, type of insulation and voltage stenciled on the jacket. Indicate insulation and jacket types and thickness, insulation color or surface printing code, UL Listing data and other data pertinent to the specific cable that demonstrates and states compliance with the specifications.
- E. Any Contractor installed, unapproved wire and/or cable shall be removed and replaced at no additional cost to the City.
- F. When factory tests are specified, provide specific details of the test conditions and a certificate that the product furnished has passed the test.

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;

2. The Wires and Cables shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 APPLICATIONS (FACILITIES ONLY)

- A. Wire for lighting and receptacle circuits above grade shall be type "XLPE (cross-linked polyethylene) High Heat-resistant Water-resistant" aka XHHW.

1.6 APPLICATIONS (LIFT STATIONS ONLY)

- A. Wire for lighting and receptacle circuits above grade shall be type "Thermoplastic High Heat-resistant Nylon coated" aka THHN.
- B. Wire for all underground shall be type XHHW.
(LIFT STATIONS ONLY)
- C. Wire for all underground shall be type THHN.
- D. Wire for all power motor circuits below 5 HP shall be type XHHW.
(LIFT STATIONS ONLY)
- E. Wire for all power motor circuits below 5 HP shall be type THHN.
- F. Single conductor wire for control, indication and metering shall be type "Machine Tool Wire" aka MTW 16 AWG, 19-strand for inside control panel applications and type XHHW 14 AWG, 19-strand for outside of control panel applications.
(LIFT STATIONS ONLY)
- G. Single conductor wire for control, indication and metering shall be type "Machine Tool Wire" aka MTW 16 AWG, 19-strand for inside control panel applications and type THHN 16 AWG, 19-strand for outside of control panel applications.
- H. Multi-conductor instrumentation/control cable:
 - I. Within a control panel shall be shielded 18 AWG, 19-strand;
 - J. In the field shall be shielded 16 AWG, 19-strand;
 - K. DLO shall be used for 5 HP motors and above from motor controller to motor connection enclosure.

1.7 MINIMUM SIZES

- A. Except for control, communication and signal leads, no conductor smaller than 16 AWG shall be used.

1.8 WIRE/CABLE TAGGING AND COLOR CODING

- A. All control circuits and wiring shall be clearly and permanently numbered and labeled at each end so as to identify the location of the opposite end and the function of the circuit. All numbering/ID tagging of cable/conductor's methods shall be in accordance with the City's Wire Tagging Standard as indicated on the Contract Drawings. Method of wire/cable tagging must be approved in a shop drawing prior to any installation. Individual wires in a multi-wire circuit shall be identified with

wire number labels as specified in this section. Labeling shall be in place prior to turnover of any equipment, system or sub-system to the City.

- B. The conductor insulation jacket of 4/0 wire and smaller shall be color coded continuous throughout the length of the wire. The installation of color coded tape on the wire conductor as a permanent marking will not be accepted.

Color code system shall be as follows:

- 1. Conductor Color Coding 208/120VAC & 480/277VAC

208/120VAC Wye

BLACK - Phase A

RED - Phase B

BLUE - Phase C

WHITE - Neutral

GREEN - Ground

480VAC Delta and 480/277VAC Wye

BROWN - Phase A

ORANGE - Phase B

YELLOW - Phase C

GRAY - Neutral

GREEN - Ground

- 2. Conductor Color Coding VDC

24/48VDC

BLUE - +24

GREY - -24

BLUE/RED STRIPE - +48

GREY/WHITE STRIPE - -48

125VDC

RED - +125V

BLACK - -125V

- C. The conductor insulation jacket of wire larger than 4/0 shall be color coded with tape every 10-foot throughout the length of the wire and at each end.

Color code system shall be as above.

- D. Wire tag labels shall be a:

- 1. Self-laminating thermal transfer label with a white printable area with a permanent acrylic adhesive;
- 2. Heat shrinkable and thermal transfer wire identification sleeves;
- 3. Refer to Section 16040 - Electrical Identification for specifics;

1.9 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 WIRE AND CABLES

- A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.
- B. All wires and cables shall be annealed, 98% conductivity, soft-drawn stranded copper conductors;
- C. Wire for Aboveground Lighting & Receptacle Circuits
- D. Acceptable Wire for Aboveground Lighting & Receptacle Circuits Manufacturers
 - 1. GENERAL CABLE® CO.
www.generalcable.com
Type XHHW;
 - 2. SOUTHWIRE® CO.
www.southwire.com
Type XHHW;
 - 3. City Preapproved Equal
- E. Wire for Aboveground Lighting & Receptacle Circuits (LIFT STATIONS ONLY)
- F. Acceptable Wire for Aboveground Lighting & Receptacle Circuits Manufacturers (LIFT STATIONS ONLY)
 - 1. GENERAL CABLE® CO.
www.generalcable.com
Type THHN;
 - 2. SOUTHWIRE® CO.
www.southwire.com
Type THHN;
 - 3. City Preapproved Equal
- G. Wire for All Underground and below 5 HP Motor Circuits
- H. Acceptable Wire for All Underground and below 5 HP Motor Circuits Manufacturers
 - 1. GENERAL CABLE® CO.
www.generalcable.com
Type XHHW;
 - 2. SOUTHWIRE® CO.
www.southwire.com
Type XHHW;
 - 3. City Preapproved Equal
- I. Wire for All Underground and below 5 HP Motor Circuits (LIFT STATIONS ONLY)
- J. Acceptable Wire for All Underground and below 5 HP Motor Circuits Manufacturers (LIFT STATIONS ONLY)
 - 1. GENERAL CABLE® CO.

- ## 2.2 INSTRUMENTATION CABLES

- City of Orlando
Conserv II Water Reclamation Facility
Preliminary Treatment System Improvements

8. Conductor Colors: Two-conductor: Black, White (or Clear), or Four-conductor: Black, White, Red, Green;
 9. For use on Security Systems, Intercom/PA Systems, Sound/Audio Systems, Power Limited Controls and Instrumentation;
 10. Analog Input/output Field Wiring, (Current/Voltage);
 11. Analog Input/output Interior Control Panel Wiring (Current/Voltage);
 12. Black (-) and White (or Clear) (+) for signal and Green (-) and Red (+) for power;
- C. Acceptable Multi-Conductor Instrumentation and Control Cable Manufacturers
1. BELDEN®
www.belden.com
Part No. 8760 Two-Conductor and
Part No. 9418 Four-Conductor PVC for control panel applications;
Part No. 6202FE Four-Conductor, FEP for field applications;
 2. GENERAL CABLE® CO.
www.generalcable.com
Part No. C2534A Two-Conductor and
Part No. C2543A Four-Conductor PVC for control panel applications;
Part No. C3341 Four-Conductor FEP for field wiring;
 3. City Preapproved Equal
- D. Analog Input (3 Wire RTD) Cable
1. Three (3) conductor;
 2. 22AWG, stranded tinned-copper conductors, shield;
 3. For non-plenum applications, use Polyvinyl Chloride (PVC) insulation and jacket;
 4. For plenum applications, use Fluorinated Ethylene Propylene (FEP) insulation and jacket;
- E. Acceptable Analog Input (3 Wire RTD) Cable Manufacturers
1. ALPHA WIRE
www.alphawire.com
Part No. 6339 PVC;
 2. BELDEN®
www.belden.com
Part No. 9939 PVC;
Part No. 83553 FEP;
 3. City Preapproved Equal

2.3 COMMUNICATION CABLES

- A. To minimize damage caused by lightning, all outdoor communication s shall use fiber-optics as specified in Section 13300. Transitions from fiber-optics to metallic cables shall be kept to a minimum.
- B. Where specified, use the appropriate specified cable for indoor or outdoor application.
- C. PROFIBUS® DP™ Cable
 1. Purple color jacket;
 2. Red/Green;

3. 2 conductor, twisted, stranded, shield;
- D. Acceptable PROFIBUS® DP™ Cable Manufacturers
 1. BELDEN®
www.belden.com
Part No. 3079E;
 2. SIEMENS INDUSTRY
www.automation.siemens.com
PROFIBUS® Flexible,
Part No. 6XV1 830-0PH10;
 3. TURCK USA
www.turck-usa.com
Part No. RB50672-999NW (999=quantity in meters on reel);
- E. PROFIBUS® DP™ Festoon Cable
 1. Purple color jacket;
 2. Red/Green;
 3. 2 conductor, twisted, stranded, shield;
- F. Acceptable PROFIBUS® DP™ Festoon Cable Manufacturers
 1. BELDEN®
www.belden.com
Part No. 3079E;
 2. SIEMENS INDUSTRY
www.automation.siemens.com
PROFIBUS® Flexible,
Part No. 6XV1 830-0PH10;
 3. TURCK USA
www.turck-usa.com
Part No. RB50672-999NW (999=quantity in meters on reel);
- G. PROFINET™ Cable
 1. Interior Control Panel Applications:
 - a. Green color jacket;
 - b. 8-core Fast Connect installation cables for cabling system with Gigabit capability;
 - c. Easy stripping with the Fast Connect Stripping Tool; the outer sheath and the braided shield are stripped accurately in one step;
 - d. Connection to IE FC RJ45 Straight Plug (AWG 24) using insulation-displacement technology;
 - e. Satisfies Category 6 (Cat6) of the international cabling standards ISO/IEC 11801 and EN 50173;
 - f. UL approval;
- H. Acceptable PROFINET™ Cable Manufacturers
 1. SIEMENS INDUSTRY
www.automation.siemens.com
IE FC TP Standard Cable 4x2 (AWG 24),
Part No. 6XV1 878-2E;
 2. City Preapproved Equal
- I. IEEE 802.3 Ethernet Cable
 1. Indoor Applications:

- a. Blue color jacket;
 - b. Eight (8) conductor (4-pair), 23 AWG solid bare copper conductors;
 - c. Fluorinated Ethylene Propylene (FEP) insulation;
 - d. Cross-web Separator;
 - e. Low-smoke, Flame-retardant Polyvinyl Chloride (PVC) jacket;
 - f. Plenum rated;
 - g. Pair colors: 1. White/Blue Stripe & Blue, 2. White/Orange Stripe & Orange, 3. White/Green Stripe & Green, 4. White/Brown Stripe & Brown;
 - h. Applications: up to and including 10 Gigabit Ethernet, 100BaseTX, 100BaseVG ANYLAN, RS-422, Noisy Environments, PoE;
- 2. Outdoor Applications:
 - a. Black color jacket;
 - b. Eight (8) conductor (4-pair), 24 AWG solid bare copper conductors;
 - c. Polyolefin (PO) insulation;
 - d. Polyethylene (PE) Unshielded jacket;
 - e. Pair colors: 1. White/Blue Stripe & Blue, 2. White/Orange Stripe & Orange, 3. White/Green Stripe & Green, 4. White/Brown Stripe & Brown;
 - f. Applications: up to and including 10 Gigabit Ethernet, 100BaseTX, 100BaseVG ANYLAN, RS-422, PoE;
- J. Acceptable IEEE 802.3 Ethernet Cable Manufacturers
 - 1. BELDEN®
www.belden.com
 For Indoor Applications:
 Part No.10GX13 Multi-Conductor - Enhanced Category 6A Non-bonded-Pair Cable;
 - 2. BELDEN®
www.belden.com
 For Outdoor Applications:
 Part No.OSP6U Multi-Conductor - Category 6 Non bonded- Pair Outside Plant Cable;
 - 3. City Preapproved Equal
- K. CAN Communication Cable
 - 1. Three conductor (CAN LOW, HIGH, GRD);
 - 2. low capacitance computer cable;
 - 3. 20 AWG, Non-Plenum;
- L. Acceptable CAN Communication Cable Manufacturers
 - 1. ALPHA WIRE
www.alphawire.com
 Part No. 2413C;
 - 2. BELDEN®
www.belden.com
 Part No. 8772;
 - 3. City Preapproved Equal

- M. RS232 Serial Communication Cable
- N. Acceptable RS232 Serial Communication Cable Manufacturers
 - 1. ALPHA WIRE
www.alphawire.com
Part No. 5471C;
 - 2. BELDEN®
www.belden.com
Part No. 9501;
 - 3. City Preapproved Equal
- O. RS485 Serial Communication Cable
- P. Acceptable RS485 Serial Communication Cable Manufacturers
 - 1. ALPHA WIRE
www.alphawire.com
Part No. 6412;
 - 2. BELDEN®
www.belden.com
Part No. 9841;
 - 3. City Preapproved Equal
- Q. Coax 50-Ohm Low Loss Flexible Communication Cable
 - 1. 11 AWG stranded;
 - 2. Single 0.108-inch bare copper conductor;
 - 3. Foam Polyethylene insulation;
 - 4. Bare copper braid shield;
 - 5. Black color non-contaminating PVC jacket;
 - 6. 300V RMS;
 - 7. UL AWM Style 1354;
- R. Acceptable Coax 50-Ohm Low Loss Flexible Communication Cable Manufacturers
 - 1. BELDEN®
www.belden.com
RG-8/U Coaxial
Part No. 8214;
 - 2. GENERAL CABLE® CO.
www.generalcable.com
RG-8/U Coaxial
Part No. C1198;

2.4 CONNECTORS

- A. Power Conductors: Terminations shall be die type or set screw type pressure connectors as specified and UL Listed for application.
- B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors per termination. Termination on screw type terminals shall be made with a maximum of two spade connectors.
- C. Splices shall not be made in push-button control stations, conduit bodies, control panels, etc.
- D. Any 480VAC splice, where approved by the Engineer, shall be compression

- type with heat shrink boot.
- E. Connectors for Aboveground Dry and Damp Locations, #8 AWG and Larger Compression lugs, splices or taps of copper alloy;
 - F. Acceptable Connectors for Aboveground Dry and Damp Locations, #8 AWG and Larger Manufacturers
 - 1. BURNDY®
www.burndy.com
BURNDY®
YAZ Long Barrel with Inspection Port Copper Compression Lug;
YS Long Barrel Copper Butt Splice Standard;
 - 2. THOMAS & BETTS
www.tnb.com
Color-Keyed® Long Barrel with Inspection Port Copper Compression Lug
Color-Keyed® YS Long Barrel Copper Butt Splice Standard
 - 3. City Preapproved Equal
 - G. Connectors for Aboveground in Light Poles, and Above or Below Ground In Manholes, Handholes and Pull Boxes
 - H. Acceptable Connectors for Aboveground in Light Poles, and Above or Below Ground in Manholes, Handholes and Pull Boxes Manufacturers
 - 1. 3M™
www.3m.com
Heat Shrink & Molded Shapes;
 - 2. THOMAS & BETTS
www.tnb.com
Shrink-Kon® Heat Shrinkable Tubing and Splice Insulators & Covers;
 - 3. City Preapproved Equal
 - I. Connectors for Aboveground, Dry and Damp Locations, #10 AWG and Smaller (aka Wire Nuts);
 - J. Acceptable Connectors for Aboveground, Dry and Damp Locations, #10 AWG and Smaller (aka Wire Nuts) Manufacturers
 - 1. 3M™
www.3m.com
Scotchlock;
 - 2. IDEAL® INDUSTRIES, INC.
www.idealindustries.com
Twister® PRO Wire Connector;
 - 3. City Preapproved Equal
 - K. RJ-45 Connector (Plug) - CAT5, Unshielded, 50-micron Clear;
 - L. Acceptable RJ-45 Connector (Plug) - CAT5, Unshielded, 50-micron Clear Manufacturers
 - 1. BELKIN®
www.belkin.com
For Round Cable,
Part No. R6G088-R-100;
For Flat Cable,
Part No. R6G088-100;

2. City Preapproved Equal
- M. RG8/U Coax N Clamp/Solder Connectors
- N. Acceptable RG8/U Coax N Clamp/Solder Connector Manufacturers
 1. AMPHENOL® CORPORATION
www.amphenolrf.com
 Type N Female RG8/U
 Part No. 082-209-1006; and
 Type N Male RG8/U
 Part No. 082-202-1006;
 2. RF INDUSTRIES
www.rfindustries.com
 Type N Female RG8/U
 Part No. RFN-1024-1SI; and
 Type N Male RG8/U
 Part No. RFN-1002-1SI;
- O. RG8/U Coax UHF UG Standard Solder Type Connector
- P. Acceptable RG8/U Coax UHF UG Standard Solder Connector Manufacturers
 1. AMPHENOL® CORPORATION
www.amphenolrf.com
 PL259 UHF Plug,
 Part No. 083-822;
 2. RF INDUSTRIES
www.rfindustries.com
 PL259 UHF Plug,
 Part No. RFU-501;

2.5 MISCELLANEOUS WIRE AND CABLE NEEDS

- A. Tape - Use as Manufacturer recommended per specific application;
- B. Acceptable Tape Manufacturers
 1. 3M™
www.3m.com
 Part No. 33 - ¾-inch x 66-feet LV Electrical;
 Part No. 130C – 1½-inch x 30-feet Linerless Rubber Splice;
 Part No. 88 - ¾-inch x 66-feet HV Electrical;
 Part No. 88 - 1½-inch x 44-feet Electrical;
 Part No. 25 - ½-inch x 15-feet Ground Braid;
 Part No. A3 - 1-inch x 75-feet Abrasive;
 Part No. 35 - ½-inch x 20-feet Code Brown;
 Part No. 35 - ½-inch x 20-feet Code Orange;
 Part No. 35 - ½-inch x 20-feet Code Yellow;
 Part No. 1755 - ¾-inch x 60-feet Friction;
 Part No. 77 - 3-inch x 20-feet Fire Arc Proofing;
 Part No. 70 - 1-inch x 30-feet Silicone Rubber;
 Part No. 69 - ½-inch x 66-feet Glass cloth;
 2. City Preapproved Equal
- C. Electrical Insulating Resins - Use per specific and approved application;

- D. Acceptable Electrical Insulating Resin Manufacturers
 - 1. 3M™
www.3m.com
 Scotchcast™
 Electrical Insulating Resin; or
 Potting Kit;
 - 2. City Preapproved Equal
- E. Seal Air Pad (Putty) - Use per specific and approved application;
- F. Acceptable Seal Air Pad (Putty) Manufacturers
 - 1. COOPER POWER SYSTEMS
www.cooperpower.com
 Kearney™ Airseal®
 Part No.18415-1
 - 2. City Preapproved Equal
- G. Pulling Lubricant - Use only cable pulling compound that is approved by the Manufacturer of the cable as being compatible with cable insulation and jacket materials. UL Listed;
- H. Acceptable Pulling Lubricant Manufacturers
 - 1. GREENLEE®
 A TEXTRON COMPANY
www.greenlee.com
 Cable-Gel™ Lubricant;
 - 2. IDEAL® INDUSTRIES, INC.
www.idealindustries.com
 Velocity™ Cable Pulling Lubricant;
 - 3. City Preapproved Equal
- I. Cable Ties & Accessories
- J. Acceptable Cable Ties & Accessories Manufacturers
 - 1. PANDUIT®
www.panduit.com
 Super-Grip™ Cable Ties,
 Weather Resistant Nylon;
 - 2. THOMAS & BETTS
www.tnb.com
 Catamount® Cable Ties,
 Ultraviolet Resistant Nylon;
 - 3. City Preapproved Equal

PART 3 - EXECUTION

3.1 GENERAL

- A. Install wires and cables in raceways.
- B. Provide a separate insulated grounding conductor in all raceways.
- C. Where conductors are to be electrically connected to metallic surfaces, polish the coated surfaces of the metal before installing the connector.
- D. All conductors shall be carefully handled to avoid kinks or damage to

insulation.

- E. All wire and cable shall be continuous and without splices between points of connection to equipment terminals. A splice will be approved by the Engineer if the length required between the points of connection exceeds the greatest standard shipping length available from the Manufacturer specified or approved by the Engineer.
- F. Contractor shall seal conduits properly prior to Substantial Completion in the presence of the City or the City's representative, NO EXCEPTIONS.

3.2 PREPARATION

- A. Remove debris and moisture from conduits, wireways, boxes and cabinets prior to conductor installation.
- B. Do not pull conductors into conduits until all work is suitable for installation of wire or cable.

3.3 INSTALLATION IN CONDUIT

- A. Use pulling means, including fish tape, cable, rope and basket weave cable grips which will not damage cables or raceways. Do not use rope hitches as pulling attachment to wire or cable. Steel fish tapes and/or steel pulling cables shall not be used in PVC conduit runs.
- B. Pull all conductors to be installed in a conduit together. Train and guide wires into the conduit using a pulling wheel and lubricant.
- C. Provide a means of communication between the pulling and guiding points to facilitate installation and to help prevent damage.
- D. Lubrications shall be used to facilitate wire pulling. Lubricants shall be UL Listed for use with the insulation specified and be fully removed from conductors immediately after installing conductors.

3.4 CONTROL AND INSTRUMENTATION WIRING

- A. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
- B. Terminate with methods consistent with terminals provided, and in accordance with terminal Manufacturer's instructions.
- C. All control and instrumentation wiring shall be installed from terminal to terminal with no splicing at any intermediate point.
- D. Shielded instrumentation wire shall be installed in dedicated conduit and pull boxes containing only shielded instrumentation cable per the Contract Drawings.
- E. Instrumentation cables shall be separated from control cables in manholes and handholes.
- F. Shielding on instrumentation cable shall be grounded at one end only, as directed by supplier of the instrumentation equipment and approved by the City's Industrial Automation Manager.
- G. Where connections of cables installed under this section are to be made by others, leave pigtails of adequate length for bundled connections.
- H. Cable Protection:

1. Under Infinite Access Floors: May be installed without bundling;
 2. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least ½ -inch in diameter;
 3. Maintain integrity of shielding of instrumentation cables;
 4. 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 shall be provided.
 - J. All communications cable shall be supplied and installed by the Contractor.

3.5 INSTALLATION IN BOXES AND CABINETS

- A. Group conductors No. 1/0 and smaller in panelboards, cabinets, pull boxes, and switchboard wireways, tie with plastic ties, and fan out to terminals. Lace conductors 2/0 and larger with appropriate sized plastic ties.
- B. Provide sufficient length of conductors within cabinets and cutout boxes to train the conductor to the terminal point with no excess.
- C. Terminate wires so that there is no bare conductor at the terminal.

3.6 WIRE SPLICING AND CONNECTING

- A. Wire and cable connections to terminals and taps shall be made with compression connectors. Connections of insulated conductors shall be insulated and covered. All connections shall be made using UL Listed materials and installation methods in accordance with instructions and recommendations of the Manufacturer of the particular item of wire and cable. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.
- B. Tighten electrical connections and terminals, including screws and bolts, in accordance with Manufacturer's published torque tightening values. Where Manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
- C. Retighten bolt-type connectors 24 to 48 hours after initial installation and before taping.
- D. Tape connections made with non-insulated-type connectors with rubber-type tape, one and one-half times the thickness of the conductor insulation, then cover with Scotch 33 tape or equal.

3.7 SPLICE MARKER

- A. Provide concrete marker to indicate location of direct burial cable splice.

3.8 CONDUIT MARKER

- A. Provide concrete marker to indicate location of capped end of conduit.

3.9 TESTS

- A. Tests shall be made at not less than 1,000 VDC.

- B. Test each complete circuit prior to energizing with a meg-ohm meter. The insulation resistance between conductors and between each conductor and ground shall not be less than 25 meg-ohms. Replace wiring of circuits that fail and repeat the test.
- C. See Section 16950 - Electrical Testing for additional testing requirements.

3.10 WARRANTY (PROJECT)

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16150

MOTORS

PART 1 - GENERAL

1.1 SCOPE

- A. Furnish and install all motors as hereinafter specified and/or as shown on the Contract Drawings. In addition, motors may be called for in other sections of these Specifications.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
- C. Motors provided shall be sufficient size for the duty to be performed and shall not exceed their full-rated load when the driven equipment is operating at specified capacity. Unless otherwise noted, motors driving pumps shall not be overloaded at any head or discharge condition of the pump.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. Anti-Friction Bearing Manufacturers Association (AFBMA) 9 - Load Ratings and Fatigue Life for Ball Bearings;
 - 2. AFBMA 11 - Load Rating and Fatigue Life for Roller Bearings;
 - 3. American National Standards Institute (ANSI) C50.41 - Polyphase Induction Motors for Power Generating Stations;
 - 4. Institute of Electrical and Electronics Engineers (IEEE) 85 - Test Procedure for Airborne Sound Measurements on Rotating Machines;
 - 5. IEEE 112 - Standard Test Procedures for Polyphase Induction Motors and Generators;
 - 6. IEEE 114 - Standard Test Procedures for Single-Phase Induction Motors;
 - 7. IEEE 620 - Guide for Construction and Interpretation of Thermal Limit Curves for Squirrel-Cage Motors Over 500 Horsepower;
 - 8. IEEE 841™ - The Petroleum and Chemical Industry-Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 500HP;
 - 9. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

10. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
11. NECA 230 - Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers;
12. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
13. National Electrical Manufacturers Association (NEMA) Premium™ Product Scope and Nominal Efficiency Levels;
14. NEC® Article 430 – Motors, Motor Circuits and Controllers;
15. NEMA MG 1 – Motors and Generators;
16. NEMA MG 13 - Frame Assignments for Alternating Current Integral Horsepower Induction Motors;
17. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum);
18. NFPA® 70E® - Electrical Safety in the Workplace;
19. Underwriters Laboratories (UL) 547 - Thermal Protectors for Electric Motors.
20. UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations;
21. UL 1004-1 - Rotating Electrical Machines - General Requirements;
22. UL 1004-2 - Impedance Protected Motors;
23. UL 1004-3 - Thermally Protected Motors;
24. UL 1004-7 - Electronically Protected Motors;
25. UL 1004-8 - Inverter Duty Motors;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. The Motor Manufacturer shall submit to the Engineer certified dimension prints showing nameplate data and outline dimensions within three (3) weeks of the date they receive the order.
- E. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Master drawing index;
 4. Dimensioned front & plan view of the assembly;
 5. Schematic diagram;

6. Descriptive information;
 7. Nameplate data in accordance with NEMA MG 1;
 8. Additional Rating Information:
 - a. Service factor;
 - b. Locked rotor current;
 - c. No load current;
 - d. Safe stall time for motors 200HP and larger;
 - e. Multi-speed 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;
 9. Enclosure type and mounting (e.g. horizontal, vertical);
 10. Dimensions and total weight.
 11. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
 12. Bearing type.
 13. Bearing lubrication.
 14. Bearing life.
 15. Space heater voltage and watts.
 16. Description and rating of motor thermal protection.
 17. Motor sound power level in accordance with NEMA MG 1.
 18. Maximum brake horsepower required by the equipment driven by the motor.
 19. Description and rating of submersible motor moisture sensing system.
 20. Provide letter stating that motors are suitable for VFD operation.
 21. Motor Full Load Current (Amps). Cable terminal sizes;
 22. Component list;
 23. Wiring diagrams;
 24. Installation information;
- F. The Motor Manufacturer shall provide a minimum five (5) year warranty letter in their submittal.

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 2. The Motor shall be posted at www.UL.com under Category Code “PRGY” and/or “PRHJ” for inverter-duty rated; Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type “PRGY” and/or “PRHJ” into the Category Code search box and click Search;

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include

recommended storage practices placed on the outside of the shipping container.

- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All motors to be installed outdoors, exposed to the weather, shall be suitable for continuous operation in 110 °F (43 °C) ambient temperature; These motors shall be Totally Enclosed Fan Cooled (TEFC), Weather-Protected Type II (WP II); unless otherwise specified;
- B. All motors to be installed indoors shall be suitable for continuous operation in 125 °F (52 °C) ambient temperature; These motors shall be Totally Enclosed Fan Cooled (TEFC), Weather-Protected Type I (WPI); unless otherwise specified;
- C. Unless otherwise specified, electrical motors shall be provided by the Manufacturer and built in accordance with UL 674, UL 1004, and NEMA MG 1. D. All motors above one (1) horsepower (HP) shall meet or exceed IEEE 841 and NEMA Premium™ standard efficiency levels contained in NEMA Standards Publication MG 1 Tables 12-12 and 12-13;
- D. All motors to be operated with variable frequency drives (VFDs) shall state they are suitable for their intended application. These motors' nameplates shall bear "Inverter Duty Rated". In addition, VFD motors shall meet the requirements of NEMA MG 1, Part 31 - Definite-Purpose Inverter-Fed Polyphase Motors;
- E. All motors weighing over 50-pounds shall be fitted with at least one (1) lifting ring or "O" type bolt;
- F. All motor enclosures shall have stainless steel screens;
- G. All motors shall be protected from corrosion, fungus and insects;
- H. All motors and equipment shall be bonded to the equipment grounding system;
- I. Refer to Section 11000 for motor efficiencies.

2.2 RATINGS

- A. All motors shall be of the low voltage type and adhere to the following power ratings:
 - 1. All below ½ HP motors shall be rated 115/230VAC, 1-phase, 60-Hertz;
 - 2. All ½ HP through 100 HP motors shall be rated 230/460VAC, 3-phase, 60-Hertz;

3. All 125 HP through 800 HP motors shall be 460VAC, 3-phase, 60-Hertz;
- B. All 10 HP and larger motors shall have a 120VAC space heater installed for moisture control;
- C. All 100 HP and larger motors and/or any VFD controlled motor shall have a thermistor type winding temperature switch, at a minimum;
- D. All 275 HP and larger motors shall have platinum-100 RTDs (2 per phase in the windings and 1 each on the bearings) and two vibration sensor transmitters, at a minimum;

2.3 FRAMES

- A. Aluminum frame motors shall not be allowed;
- B. Steel frame motors shall be permitted with motor frames 184 and smaller;
- C. Cast iron for motor frames 184 and larger shall be provided;

2.4 NAMEPLATES

- A. All motor nameplates shall be permanently fastened to the motor frame and be positioned for easy visibility;
- B. Motor nameplates shall be stamped stainless steel and include those items enumerated in NEMA Standard MG 1;
- C. Nameplates for high efficiency motors shall list the nominal efficiency;
- D. Nameplates for explosion-proof motors shall indicate frame temperature limit code;

2.5 FRACTIONAL HORSEPOWER MOTORS

- A. Fractional horsepower motors shall be rigid, welded steel, designed to maintain accurate alignment of motor components and provide adequate protection.
- B. End shields shall be reinforced, lightweight die-cast aluminum.
- C. Windings shall be of varnish-insulated wire with slot insulation of polyester film, baked-on bonding treatment to make the stator winding strongly resistant to heat, aging, moisture, electrical stresses and other hazards;
- D. Motor shaft shall be made from high-grade, cold-rolled shaft steel with drive-shaft extensions carefully machined to standard NEMA dimensions for the particular drive connection;
- E. For light to moderate loading, bearings shall be quiet all-angle sleeve type with large oil reservoir that prevents leakage and permits motor operation in any position;
- F. For heavy loading, bearings shall be carefully selected precision ball bearings with extra quality, long-life grease, and large reservoir providing 10-years normal operation without additional lubrication;

2.6 SINGLE-PHASE MOTORS

- A. Single-phase motors shall be split-phase and capacitor-start induction types rated for continuous horsepower at the RPM called for on the Contract Drawings; Motors shall be rated 115/230VAC, single-phase 60-Hertz, open drip-proof, or totally enclosed fan cooled with Class B Insulation;

- B. Totally Enclosed Fan Cooled (TEFC) motors shall be designed for severe-duty;
- C. Motors shall have corrosion and fungus protective finish on internal and external surfaces; All fittings shall have corrosion protective plating;
- D. Mechanical characteristics shall be the same as specified for polyphase fractional horsepower motors;

2.7 THREE-PHASE MOTORS

- A. Motors shall be of the squirrel-cage or wound rotor induction type; Horizontal, vertical solid-shaft, vertical hollow-shaft, normal thrust or high-thrust shall be furnished as specified;
- B. All motors shall have normal or high starting torque (as required), low starting current (not to exceed 600% FLA), and low slip;
- C. All motors shall have a 1.15 Service Factor and Class H Insulation;
- D. All motors shall be suitable for operation in moist air with hydrogen sulfide gas present;
- E. The output shaft shall be suitable for direct connection or belt-drive as required;
- F. All interior and exterior surfaces of motors shall have a final coating of chemical resistant corrosion and fungus protective epoxy fortified enamel finish spray over red primer applied; Stator bore and rotor of all motors shall be epoxy coated;
- G. All fittings, bolts, nuts and screws shall be Type 316 stainless steel; Bolts and nuts shall have hex heads;
- H. All machine surfaces shall be coated with rust inhibitor for easy disassembly;
- I. All conduit boxes shall be oversized, if offered, and supplied with a petroleum resistant gasket; In addition, lead wires between motor frame and conduit box shall be supplied with a petroleum resistant gasket;
- J. Totally enclosed motors shall be provided with condensate drain hole and epoxy coated motor windings to protect against moisture;
- K. Motor frames and end shields shall be cast iron or heavy fabricated steel of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type of enclosure employed;
- L. Windings shall be adequately insulated and securely braced to resist failure due to electrical stresses and vibrations;
- M. The shaft shall be made of high-grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of the particular rating. Bearing journals shall be ground and polished;
- N. Rotors shall be made from high-grade steel laminations adequately fastened together and to the shaft; Rotor squirrel-cage windings may be cast-aluminum or bar-type construction with brazed end rings;
- O. Motors shall be equipped with vacuum-degassed anti-friction bearings made to AFBMA Standards and be of ample capacity for the motor rating; The bearing housing shall be large enough to hold sufficient lubricant to

minimize the need for frequent lubrication, but facilities shall be provided for adding new lubricant and draining old lubricant without motor disassembly; The bearing housing shall have long, tight, running fits or rotating seals to protect against the entrance of foreign matter into the bearings, or leakage of lubricant out of the bearing cavity;

- P. Bearings of high-thrust motors shall be locked for momentary up-thrust of 30% down-thrust; All bearings shall have a minimum B10 life rating of 100,000-hours in accordance with AFBMA life and thrust values;
- Q. Vertical hollow-shaft motors shall have non-reverse ratchets to prevent backspin;

2.8 ACCEPTABLE MOTOR MANUFACTURERS

- A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

- 1. ABB, INC.
BALDOR ELECTRIC COMPANY
www.abb.com
www.baldor.com
Super-E®
Premium Efficiency Series;
- 2. NIDEC MOTOR CORPORATION
www.nidec-motor.com
U.S. Motors® 841 PLUS®;
- 3. SIEMENS INDUSTRY
www.sea.siemens.com
Severe & Inverter Duty Series;

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All motors shall be connected to the conduit system by means of a short section (minimum 18-inch) of flexible conduit unless otherwise indicated; For all motor connections, the CONTRACTOR shall install a grounding conductor in the conduit and terminate at the motor control center with an approved grounding clamp;

3.2 ADJUSTING AND CLEANING

- A. The motors shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.3 TESTING

- A. The following tests shall be performed on all motors after installation, but before placing the motors in service;
- B. The CONTRACTOR shall megger each motor winding before energizing the motor, and if insulation resistance is found to be low, shall notify the Engineer and shall not energize the motor;
- C. The following table gives minimum acceptable insulation resistance in meg-ohms at various temperatures and for various voltages with readings being taken after one minute of megger test run:

Degree Winding Temperature	Degree Winding Temperature	Voltage	Voltage	Voltage	Voltage
°F	°C	115VAC	230VAC	460VAC	4,160VAC
37	3.9	60	108	210	1,700
50	10	32	60	120	1,000
68	20	13	26	50	460
86	30	5.6	11	21	195
104	45	2.4	4.5	8.8	84
122	50	1	2	3.7	35
140	60	0.5	0.85	1.6	15

- D. The CONTRACTOR shall check all motors for correct clearances, alignment and lubrication; If lubrication is low, the CONTRACTOR shall add lubricate per Manufacturer's instructions;
- E. The CONTRACTOR shall check direction of rotation of all motors and reverse connections at the conduit box, if necessary;
- F. All motors shall be given the standard short commercial test prior to shipment; This test shall consist of no-load current; check current balance; winding resistance; air gap measurement; high potential tests and bearing inspection; Six (6) hard-copies and one (1) electronic copy in Adobe Acrobat Portable Document Format (PDF) of the certified short commercial test shall be sent to the Engineer prior to shipment;
- G. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service.
- B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- C. Verify that all motors are installed and connected according to the Contract Documents.

- D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
- E. Verify that wiring installation complies with requirements in Division 16 Sections.
- F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

- A. Motor Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for a minimum of five (5) years from date of Substantial Completion.

3.6 WARRANTY (PROJECT)

- A. All equipment furnished and installed under this Section shall be guaranteed against defects of workmanship, materials and improper installation for a period of one (1) year from Substantial Completion. Any such equipment or parts proven defective, due to the above noted causes, shall be replaced by the CONTRACTOR at no cost to the City.
- B. Motor Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for a minimum of five (5) years from date of Substantial Completion.

End of Section

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PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE

- A. Contractor shall furnish all labor, materials, equipment and incidentals required and install all panelboards as hereinafter specified and as shown on the Contract Drawings.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) / Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
 - 2. ANSI/UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
 - 3. ANSI/UL 67 – Panelboards;
 - 4. ANSI/UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures;
 - 5. ANSI/UL 508A - Industrial Control Equipment;
 - 6. ANSI/UL 1449 - Surge Protective Devices (3rd edition);
 - 7. ANSI/UL 1053 - Ground-Fault Sensing and Relaying Equipment;
 - 8. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 9. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 10. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards;
 - 11. National Electrical Code (NEC®) 240 – Overcurrent Protection;
 - 12. National Electrical Manufacturers Association (NEMA) Standard PB 1 - Panelboards;
 - 13. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 14. NEC® Article 250 – Grounding and Bonding;
 - 15. NEC® Article 285 – Surge-Protective Devices (SPDs), 1kV or Less;

16. NEC® Article 312 – Cabinets, Cutout Boxes, and Meter Socket Enclosures;
17. NEC® Article 314 – Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Handhold Enclosures;
18. NEC® Article 404 – Switches;
19. NEC® Article 408 – Switchboards and Panelboards;
20. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Master drawing index;
 4. Dimensioned front & plan view of the assembly;
 5. Schematic diagram;
 6. Bus connection;
 7. Connection details;
 8. Cable terminal sizes;
 9. Component list;
 10. Conduit space entry/exit locations;
 11. Wiring diagrams;
 12. Installation information;

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements –
 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 2. The Panelboard shall be posted at www.UL.com under Category Code “QEUY”, “QFIW”, “QFKR” and/or “QFOF”. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type “QEUY”, “QFIW”, “QFKR” and/or “QFOF” into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 RATINGS

- A. Panelboard ratings shall be as shown on the Contract Drawings. All panelboards shall be rated for the intended voltage, environment and application. All panelboards shall have a copper bus; bolt-in type circuit breakers with grounding and lug kits and integral surge protection device.
- B. Panelboards and bolt-in type circuit breakers shall be suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity.
- C. Short-Circuit Current Equipment Rating shall be fully rated. Series connected is unacceptable to the City.
- D. Minimum ratings applicable with available short-circuit current of 25,000 amperes RMS symmetrical at 208Y/120VAC or 120/240VAC and 65,000 amperes RMS symmetrical at 480Y/277VAC.
- E. Where ground fault interrupter circuit breakers are indicated or required by code, these breakers shall be 5 mA trip, 10,000 amps interrupting capacity circuit breakers.
- F. All panelboards provided shall provide a minimum of six (6) spare circuit spaces for future expansion.

2.2 SINGLE MANUFACTURER

- A. The Manufacturer of the panelboards, bolt-in type circuit breakers with grounding and lug kits and integral surge protection device shall be the same Manufacturer.

2.3 CONSTRUCTION (NEMA 1 AND NEMA 4X)

- A. Interiors
 - 1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solder-less type and all shall be suitable for copper wire of the sizes indicated;
 - 2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus

connectors and shall be so designed that circuits may be changed without machining, drilling or tapping;

3. Branch circuits shall be arranged using double row construction. Branch circuits shall be numbered by the Manufacturer.
4. A nameplate shall be provided listing panel type, number of circuit breakers and ratings;

B. Buses

1. Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be copper.
2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.
4. Buses for 480V panelboards shall be rated for 65,000 amperes RMS symmetrical. Buses for 120/208V light panels shall be rated 10,000 amperes RMS symmetrical.

C. Surge Protection Devices (SPDs)

1. All panelboards shall include integral bus mounted surge protection devices per Section 16709 -Protectors and Surge Protection Devices.

D. Boxes

1. NEMA 1 – Inside, non-corrosive areas features:
 - a. Surface mounted boxes shall have an internal and external finish as specified in Section 16160.2.03.E.6.
 - b. At least four (4) interior mounting studs shall be provided.
 - c. All conduit entrances shall be field punched;
2. NEMA 4X – Corrosive and outside areas features:
 - a. Panelboard shall be contained within a Type 316 Stainless Steel enclosure with continuous hinge and three-point latch;
 - b. The three-point latch handle shall accept a 2 x 3/8-inch diameter shackle padlock;
 - c. Door circuit directory frame and card having a transparent cover shall be furnished on each door;
 - d. All conduit entrances shall be field punched.

E. Trim for NEMA 1 Panelboards Only

1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48-inches in height shall have a vault handle and 3-point latch complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed;
3. Door circuit directory frame and card having a transparent cover shall be furnished on each door;

4. Lock shall be YALE Cabinet Lock Model No. 511S, keyed to YALE Key No. 47; Two keys shall be supplied for each lock; All locks shall be keyed alike;
 5. The trims shall be fabricated from code gauge sheet steel.
 6. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with ANSI Z55.1, No. 61 light gray paint over rust inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere.
 7. Trims for flush panels shall overlap the box by at least $\frac{3}{4}$ -inch all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.
- F. Circuit Breakers
1. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.
 2. Meets UL 489 which incorporates NEMA AB 1;
 3. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle
 4. Non-interchangeable, in accordance with NFPA® 70
 5. Provisions for handle padlocking, unless otherwise shown
 6. Circuit breakers shall be molded case, bolt-in type ONLY – NO EXCEPTIONS;
 7. Multi-pole circuit breakers designed to automatically open all poles when an overload occurs on one pole;
 8. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers
 9. Do not use tandem or dual circuit breakers in normal single-pole spaces
 10. Circuit breakers used in 120/240VAC and 120/208VAC panelboards shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.
 11. Three pole breakers used in 480VAC panelboards shall have an interrupting capacity of not less than 65,000 amperes RMS symmetrical.
 12. GFCI (ground fault circuit interrupter) shall be provided for circuits where indicated on the Contract Drawings. GFCI units shall be 1-pole, 120VAC, molded case, bolt on breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be UL Listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time), and an interrupting capacity of 10,000 amperes RMS.

2.4 ACCEPTABLE PANELBOARD MANUFACTURERS

- A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

1. EATON CORPORATION

www.eaton.com

CUTLER-HAMMER®

Pow-R-Line (PRL) 1a, 2a, 3a, 3E and 4 Series with SPD Series Integrated Unit;

PRL1a = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

PRL2a = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

PRL3a = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

PRL3E = 480A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

PRL4 = 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;

SPD with Surge Counter;

2. SIEMENS INDUSTRY

www.sea.siemens.com

Type P1, P2, P3, P4 and P5 Series with Integral Sentron® Transient Protection System (TPS3);

P1 = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

P2 = 600A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

P3 = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

P4 = 800A Max Main; 1200A Max Main Lugs Only; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;

P5 = 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;

TPS3 with Surge Counter;

3. **SQUARE D**

Type NQ (QOB) Series with SPD Series Integrated Unit;

I-Line=400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

I-Line = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

I-Line = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

I-Line 480A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;

I-Line 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;

SPD with Surge Counter.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Boxes for surface mounted panelboards shall be mounted so there is at least ½- inch air space between the box and the wall.
- B. Unless otherwise noted on the Contract Drawings, top of cabinets shall be mounted 6-feet, 0-inch above the floor, properly aligned and adequately supported independently of the connecting raceways.
- C. All wiring in panelboards shall be neatly formed, grouped, laced, and identified to provide a neat and orderly appearance.
- D. A typed directory card identifying all circuits shall be placed in the cardholder inside the front cover. Electronic file(s) in either Microsoft® Word® (.doc or .docx format) or Excel® (.xls or .xlsx format) shall be delivered with the as-built files prior to Substantial Completion.

3.2 ADJUSTING AND CLEANING

- A. The panelboards shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.3 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service.
- B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- C. Verify that all panelboards are installed and connected according to the Contract Documents.
- D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
- E. Verify that wiring installation complies with requirements in Division 16 Sections.
- F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.6 WARRANTY (PROJECT)

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes materials and installation of supporting devices to securely support electrical items from building structures by means of hangers, supports, anchors, sleeves, inserts seals and associated fastenings.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) / Underwriters Laboratories (UL);
 - 2. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 3. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 5. NFPA® 70E® - Electrical Safety in the Workplace;
 - 6. UL 5B - Strut-Type Channel Raceways and Fittings;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media

shall be provided.

- D. Contractor shall submit product data for each type of product specified.
- E. Contractor shall submit shop drawings for supplementary framing. Show design loads, member sizes and locations.

1.4 QUALITY ASSURANCE

- A. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
- B. The Supporting Devices shall be posted at www.UL.com under the appropriate Category Code; Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search;

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Protect supports, support hardware, and fasteners with zinc coating or with treatment of equivalent corrosion resistance using reviewed alternate treatment, finish, or inherent material characteristic.
- B. Contractor shall choose material and finish compatible with other metal in area (i.e. stairs, grating, air ducts, etc.).

2.2 HANGERS, STRAPS AND BEAM CLAMPS

- A. Hangers shall be Type 316 stainless steel;
- B. One-hole and two-hole straps shall be Type 316 stainless steel with "Clamp Backs";
- C. Beam clamps shall be Malleable iron, hot-dipped galvanized;
- D. Acceptable Hanger, Strap and Beam Clamp Manufacturers
 - 1. EGS ELECTRICAL GROUP
www.egseg.com
www.o-zgedney.com
 O-Z/GEDNEY Brand;

2. THOMAS AND BETTS CO.
www.tnb.com
 STEEL CITY® Brand;
 KINDORF® Brand;
 OR
 SUPERSTRUT® Brand;
3. City Preapproved Equal

2.3 SUPPORT & FRAMING CHANNELS AND FITTINGS

- A. Channels for Dry, Wet and Corrosive Areas shall be Type 316 stainless steel, 12-gauge minimum;
- B. Fittings shall be Type 316 stainless steel;
- C. All installations shall include protective end caps;
- D. Acceptable Support & Framing Channel and Fitting Manufacturers
 1. ATKORE INTERNATIONAL
www.unistrut.com
 UNISTRUT® CORP.
 P1000T Series;
 2. COOPER B-LINE®
www.cooperbline.com
 Strut Systems & Bolted Framing Products, B22SH SS6 Series;
 3. City Preapproved Equal

2.4 ANCHORS

- A. Mechanical anchoring systems shall be Type 316 stainless steel self-drilling and expansion bolt types;
- B. Acceptable Anchor Manufacturers
 1. ITW RED HEAD (formerly (ITT) PHILLIPS DRILL CO.)
www.itw-redhead.com
 RED HEAD® Products;
 2. POWERS FASTENERS INC. (formerly RAWL PRODUCTS CO.)
www.powers.com
 POWERS Products;
 3. City Preapproved Equal

2.5 HARDWARE

- A. All Hardware shall be Type 316 stainless steel including screws, nuts, bolts, washers, etc.;
- B. Acceptable Hardware Manufacturers
 1. City Approved

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and

permanently in accordance with NEC® requirements.

- B. Coordinate with building structural system and with other electrical and mechanical installations.

3.2 CONDUIT SUPPORTS

- A. Conform to Manufacturer's recommendations for selection and installation of supports.
- B. Strength of each support shall be adequate to carry present and future load with a safety factor of at least four, or 200 pounds, whichever is greater.
- C. Do not use perforated strap or plumbers tape for conduit supports.
- D. RGS Conduit on Concrete or Masonry:
 - 1. Use one-hole malleable iron clamps with pipe spacers (clamp backs) or preformed Type 316 stainless steel channels.
 - 2. Anchor with metallic expansion anchors and screws or from preset inserts.
 - 3. Use present inserts in pre-stressed concrete.
 - 4. On plaster or stucco, use one-hole stainless steel straps with stainless steel toggle bolts.
- E. Supports at Structural Steel Members: Use Type 316 stainless steel beam clamps.
- F. Wherever conduit may be affected by dissimilar movements of the supporting structures or medium, provide flexible or expansion devices.

3.3 ADJUSTING AND CLEANING

- A. The devices described in this section shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.

3.4 TESTING

- A. Perform installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.5 STARTUP SERVICES

- A. Verify that all devices are installed and connected according to the Contract Documents.
- B. Verify that installation complies with requirements in Division 16 Sections.
- C. Complete installation and startup checks according to Manufacturer's written instructions.

3.6 WARRANTY

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

SECTION 16265

UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall furnish and install a three-phase continuous duty, on-line, double conversion, solid-state uninterruptible power system, hereafter referred to as the UPS with a minimum battery backup time of 30 minutes. The UPS shall operate in conjunction with the building electrical system to provide power conditioning, back-up and distribution for critical electrical process instrumentation loads as shown on the electrical drawings. The UPS shall consist of the UPS module, batteries or other DC storage systems, and accessory cabinets for maintenance bypass and distribution applications, and other features as described in this specification.

1.02 RELATED SECTIONS

1.03 SYSTEM DESCRIPTION

The UPS system will include a minimum of (1) rectifier, (1) inverter, (1) static bypass, (1) maintenance bypass, (1) battery system and associated control and monitoring panel.

- A. Components:
 - 1. Rectifier
 - 2. Inverter
 - 3. Sealed Lead Acid Batteries
 - 4. Battery Charger
 - 5. Automatic Bypass
 - 6. User Interface Panel
 - 7. Serial (RS-232) Communication Interface
 - 8. Communication Card Slots (2)
 - 9. Relay Output Contact (2)
 - 10. Environmental Inputs (2)

11. Hardwired Input, Output
 12. External Matching Battery Cabinets
 13. Maintenance Bypass Module
 - a. MBP internal to UPS module
 14. SNMP/Web Adapter
- B. Modes of Operation: The UPS shall operate as an online, double-conversion UPS with the following modes:
1. Normal During the Normal or Double-conversion Mode the rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the online inverter. The inverter shall convert the DC power to highly regulated and filtered AC power for the critical loads.
 2. Battery Upon failure of the AC input source, the critical load must continue to be supplied by the inverter without switching. The inverter must obtain its power from the battery. There must be no interruption in power to the critical load upon failure or restoration of the AC input source.
 3. Recharge Upon restoration of the AC input source, the rectifier/battery charger must recharge the battery. The inverter shall, without interruption of power, regulate the power to the critical load.
 4. Bypass: The static bypass switch must be used for transferring the critical load to the AC utility supply without interruption. Automatic re-transfer to normal operation must also be accomplished without interruption of power to the critical load. The static bypass switch must be capable of manual operation.
 5. Integral Maintenance Bypass: The maintenance bypass is used for supplying the load directly from the AC utility supply, while the UPS is isolated for maintenance or repair.
- C. The UPS and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.
1. Safety
 - a. IEC 62040-1-1 or EN 62040-1-1

b. EN 60950

c. UL 1778

2. Emission and Immunity:

a. EN 50091-2 (Emissions Class A and Harmonics)

b. EN61000-4-2,-3,-4,-5 - Slow high energy surges in input/output lines: 1 kV. line/earth, 0.5 kV line/line (IEC 61000-4-5) - Fast low energy transients in power lines: 2 kV. line/earth (IEC 61000-4-4) - Fast low energy transients (burst) in control and signal lines: 1 kV line/earth (IEC 61000-4-4) - Electrostatic discharge (ESD): 8 kV air discharge, 6 kV contact discharge (IEC 61000-4-2) - Electromagnetic field: IEC 61000-4-3 level 3

c. FCC Class A15J

D. Markings

1. UL and NOM

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. Submit one copy of a concise operation and maintenance manual.

1.05 SUBMITTALS – FOR CONSTRUCTION

A. Submit one copy of a concise operation and maintenance manual.

1.06 QUALIFICATIONS

A. The manufacturer of the unit shall have a minimum of forty years experience in the design, manufacture, and testing of Uninterruptible Power Supplies.

B. For the equipment specified herein, the manufacturer shall be ISO 9001.

C. Provide Seismic tested equipment as follows:

1. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through zone 4 application.

1.07 REGULATORY REQUIREMENTS

A. The UPS shall be UL labeled.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.09 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component, products.

1.10 MANUFACTURERS

- A. Eaton /Powerware, Schneider Electric – APC or approved equal.

1.11 RATINGS

- A. System Input
 - 1. Input Voltage Operation Range
 - a. Nominal 120/208 VAC, 4-wire plus ground
 - b. +10% to –15% from nominal
 - 2. Input Frequency
 - a. 45 to 65 Hz
 - b. auto-sensing
 - c. capable of 50 to 60 Hz or 60 to 50 Hz frequency conversion
 - 3. Input Power Factor: 0.99 typical
 - 4. Input Current Distortion: 5% THD maximum at full rated linear load
 - 5. Inrush Current:
 - a. <2x branch rating without input transformer
 - b. <5x branch rating with input transformer
 - 6. Surge Protection:
 - a. Line to Line 180J

- b. Line to Ground 450J
- B. System Output, Normal Mode -Nominal Output Voltage 208/120 VAC, Selectable through front panel or through serial port connection with power management software.
 - 1. Voltage regulation: +/-2% of selected output voltage in steady state
 - 2. Transient Voltage Response: Meets Class 1 performance of IEC62040-3
 - 3. Voltage THD:
 - a. 2% Total Harmonic Distortion (THD) maximum phase to neutral into a maximum rated linear load (5% phase to phase)
 - b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)
 - 4. Nominal Frequency: 50 or 60 Hz selectable
 - 5. Frequency Regulation:
 - a. 50/60 Hz +/- 0.5 to +/- 3.0 Hz selectable, synchronized to mains, +/- 0.005 Hz free running single units
 - b. +/- 0.15 Hz parallel units
 - 6. Slew rate:
 - a. selectable to 1.0, 2.0, 3.0 Hz/s for single units,
 - b. < 0.5 Hz/s for parallel units;
 - c. Generator Mode (6 / 7.5 Hz/s) for single units selectable through software parameters that can be configured via LCD and service PC interface
 - 7. Output Current: Maximum output current (at nominal output voltage) for the UPS shall be:
 - a. 15 kVA system: 41.6 A @ 208 V
 - 8. Current Overload Capability without Bypass:
 - a. 125% for 1 min
 - b. 150% for 5 seconds

- c. >150% for 300 ms
- 9. Bypass:
 - a. Automatic bypass shall provide an alternate path to power in the case of overload, inverter failure or other UPS failure
 - b. Internal Maintenance Bypass can be utilized with the UPS to allow servicing of the UPS
 - c. Transfer time to and from any internal bypass shall be no-break
- 10. Efficiency: Typical >91% while in normal mode, with nominal line conditions

C. System Output, Battery Mode

- 1. Nominal Output Voltage: This shall be the user-selected output voltage
- 2. Voltage Regulation: +/-1% phase to neutral of selected nominal voltage (+/-2% phase to phase)
- 3. Transient Voltage Response
 - a. Meets Class 1 performance of IEC62040-3
 - b. +/-5% for 100% step load change; recovery in <1ms
- 4. Voltage THD:
 - a. 2% Total Harmonic Distortion (THD) maximum into a maximum rated linear load
 - b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)
- 5. Frequency Regulation: +/-0.005 Hz of selected nominal frequency
- 6. Overload Capacity:
 - a. 125% for 1 min
 - b. 150% for 5 seconds
 - c. >150% for 300 ms

1.12 CONSTRUCTION

- A. The UPS system shall be provided as a single-module, non-redundant system. The UPS shall be field-upgradeable for power rating 15 kVA, additional parallel capacity or for redundant operation. The system shall be configured with the following options:
 - 1. External Matching Battery Cabinets
 - 2. Several Connectivity Options
 - 3. Internal Maintenance Bypass Switch
- B. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The rectifier corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the DC-DC converter shall be supplied power without interruption from the internal or external batteries.
 - 1. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least five (5) seconds if no bypass is available.
- C. Inverter: The inverter converts the DC power from the rectifier or converter to regulated AC power for output to critical loads.
 - 1. Output Voltage: The inverter output voltage is specified in section 1.12.B.
 - 2. Voltage Regulation: The inverter steady state voltage regulation is +/- 1% phase to neutral, 2% phase to phase. Dynamic regulation meets Class 1 performance of IEC62040-3.
 - 3. Frequency Control: The inverter steady state frequency regulation is +/- 0.005 Hz, free running in steady state. UPS is synchronized to Utility in normal operation.
- D. Mechanical Construction
 - 1. All materials and components of the UPS shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing. The UPS shall be constructed of replaceable subassemblies. All active electronic devices shall be solid-state.
 - 2. The UPS unit is comprised of an input rectifier, battery charger, inverter, bypass, and battery consisting of the appropriate number of sealed battery modules, and shall be housed in a single freestanding enclosure. The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. Casters and leveling feet shall be provided as standard.
 - 3. Matching external battery cabinets shall be available in different sizes.

4. Dimensions of standard UPS and external battery or option cabinets:

<u>Enclosure</u>	<u>Dimensions (H x W x D)</u>	<u>Weight (inc. bat)</u>
UPS:	66 x 20 x 34 inches	1105 lbs
½ BATTERY CAB:	66 x 20 x 31 inches	1100 lbs
FULL BATT CAB:	66 x 20 x 31 inches	2060lbs
OPTION CAB MBP ONLY:	66 x 20 x 34 inches	205 lbs
OPT CAB W/TRANSFORMER:	66 x 20 x 34 inches	535 lbs

1.13 SYSTEM INPUT & OUTPUT CONNECTIONS

A. AC Input:

1. All UPS units shall be capable of utilizing hardwired input. Option cabinets will contain sufficient power cabling to connect to the UPS power terminals when the Option cabinets are placed adjacent to the UPS.
2. Input neutral is required for proper UPS operation unless input transformer option is used.

B. AC Output:

C. All UPS units shall be capable of utilizing hardwired output

D. Extended Battery Connector: External battery cabinets include cable to connect each battery cabinet to the UPS or daisy chain external battery cabinets.

E. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS alarm status.

F. (2) Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.

G. (2) Programmable Input Connections: The UPS shall provide built-in inputs for field connection (environmental input). The inputs shall be parameter programmable to suit the needs of the application.

1.14 USER INTERFACE

A. Front Panel Display: The UPS shall include a front panel display consisting of a graphical LCD display with backlight, four status LED's, and a four-key keypad.

1. Graphical LCD display: Includes basic language (English and local selectable language), display of unit function and operating parameters. It shall be used to signify the operating state of the UPS, for indicating alarms, for changing operations control parameters and set points.
 2. Four status LED's, which indicate:
 - a. Alarms, with a red LED
 - b. On Battery, with a yellow LED
 - c. On Bypass, with a yellow LED
 - d. Power On, with a green LED
 3. Four-Key Multifunction Keypad: UPS shall have keypad to allow user to adjust UPS parameters, view alarm and inverter logs, change UPS operational modes, and turn the UPS on and off.
- B. Power Management Software Package: The UPS shall include serial communications interface that provides the following communication capabilities:
1. Monitor and graphically display input and output voltage and other operating characteristics
 2. Notify end-users in the event of a power anomaly via network, E-mail or page.
 3. Communication Ports:
 - a. Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.
 - b. Serial communications (via RS-232) with manufacturer-supplied power management software package

1.15 BATTERIES

- A. Battery Type: Valve Regulated Lead Acid (VRLA), minimum two-year warranted float service life at 25 degrees C
- B. UPS Holdover Time (Runtime): Each UPS system, consisting of a minimum of six battery strings (108 battery blocks) for each power module shall have a minimum holdover time of 11 minutes, depending on kVA rating.

- C. Extended Holdover Time (Runtime): Each UPS system shall have capability for addition of extra matching battery cabinets (in two cabinet configurations) to increase the total holdover time. Please refer to datasheet for a list of runtimes. The battery times listed are approximate and may vary depending on load configuration, temperature, battery age, and battery charge.
- D. Battery Recharge Time:
1. Base UPS system consisting of six (6) battery strings will have a recharge time of max. 1.75 hours to 95% usable capacity @ nominal line after a full load discharge (30 kVA).
- E. Bus Voltage: Nominal bus voltage is 216 VDC. Each string consists of 18 battery blocks in series with 9 Ah capacity.
- F. Battery Protection:
1. Short Circuit Protection: Over-current protection shall protect the batteries from all short circuit fault conditions
 2. Battery Module Protection: Internal battery circuit breaker shall be provided
 3. Under-voltage Protection:
 - a. Inverter cutoff voltage: Battery operation shall be terminated when the battery voltage drops to the 1.67 VPC set point
 - b. Protective shutdown voltage: Inverter shall shutdown after 1 minute when the battery voltage drops below 1.7 VPC volts-per-cell typical
 4. Over-voltage Protection: If the UPS system's battery bus voltage exceeds the predetermined set point then the UPS will disable the charger and alarm a high battery condition
- G. Advanced Battery Management:
1. Battery recharge: After recharging batteries to full capacity, the charger will enter the rest mode to increase the battery lifetime according the ABM cycle. Hence, continuous float charging of the battery shall not be allowed. The active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).
 2. Battery Runtime Monitoring: UPS shall monitor batteries and provide status to end user of battery runtime via front panel, serial

communications, or both. Runtime calculations to be based on load demand and analysis of battery health.

3. Battery Health Monitoring: UPS shall periodically test and monitor battery health and provide warnings visually, audibly and/or serially when battery capacity falls below 80% of original capacity. Battery testing may also be user initiated via front panel or serial communications.

1.16 NAMEPLATES

- A. Provide a printed nameplate for the UPS.

1.17 ENVIRONMENTAL CONDITIONS

- A. The UPS shall be certified to the following safety standards:
 1. EN 62040-1-1, IEC 62040-1-1, EN 60950
- B. The UPS shall meet CISPR22 Class A (EN50091-2) for Emissions and EN50091-2 (IEC6100032 for 16 amps or less) for Harmonics
- C. Audible Noise: Less than 57 dBA (A weighted) at one (1) meter from all sides in all system modes
- D. Ambient Temperature
 1. Operating: UPS 0 deg C to +40 deg C
 2. Storage: UPS 0 deg C to +25 deg C
- E. Relative Humidity
 1. Operating: 5 to 95% non-condensing.
 2. Storage: 5 to 95% non-condensing.
- F. Altitude
 1. Operating: To 3000 meters--de-rating or reducing operating temperature range may be required for higher altitudes
 2. Transit: To 10,000 meters
- G. Electrostatic Discharge: The UPS shall be able to withstand a minimum 8 kV without damage and without affecting the critical load

PART 2 EXECUTION

2.01 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.
 - 1. Standard Computer-automated UPS system test
 - 2. Hipot test

2.02 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's recommendations.

2.03 FIELD QUALITY CONTROL

- A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 2 working days. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
- B. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

2.04 WARRANTY

- A. All components of the UPS system shall be covered by a standard one-year limited factory warranty and service protection package.
- B. One-year limited factory warranty shall include replacement coverage for the UPS parts for a period of 18 months from shipment or 12 months from start-up, whichever occurs sooner. Labor coverage is for 90 days after product startup.
- C. One-year service protection package shall include 7x24 on-site repair/replacement labor for UPS parts and batteries; 7x24 technical support coverage; and 7x24 remote monitoring service (with monthly reports for UPS and battery performance). Standard response time shall be 8 hours from receipt of call. Manufacturer shall also offer, as an option, 7x24 on-site service support with guaranteed response times of 4, or 2 hours in certain major metropolitan areas. Additional preventive maintenance visits shall be available as an option for both UPS and battery components.

- D. Manufacturer shall also include Start-up services consisting of: 7x 24 Start-up service of UPS and batteries. On-site user training, Site Audit, installation and commissioning of monitoring service, and validation of one-year limited factory warranty will be performed during the start-up.
- E. Manufacturer shall also offer an optional service plan to provide 7x24 on-site coverage (preventive and corrective) for UPS and batteries, guaranteed response time, remote monitoring, Web access to service site history, annual Site Audit, UPS and battery preventive maintenance visit, and discounts on upgrade and modification kits. Manufacturer shall also provide a battery service plan to provide parts-and-labor coverage for partial and full battery strings, either with preventive maintenance or replacement coverage.

END OF SECTION

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SECTION 16325 480-VOLT SWITCHGEAR

SECTION 16106 480-VOLT SWITCHGEAR

FOR INFORMATION PURPOSES ONLY

Change Log:

3/1/2016 Changed requirement from NEMA 12 to simply say NEMA rated. NEMA 1 is standard for SG.

12/08/14 16325-2.02.13 has been revised to reflect the current Systems Standard Drawings.

11/21/14 added "Integrated Local/Remote switch" to Circuit Breaker features;

11/18/14 Vendor review and changes;

11/17/14 Added spare breaker requirements;

11/06/14 Added remote racking and local open/close devices. Updated communications specifications to reflect OWNER's LOW VOLTAGE STANDARDS. Added features to switchgear components for enhanced electrical safety, NFPA 70, and NFPA 70e;

1/14/14 clarified corrugated switchboard matting;

09/13/16 added cubicle protection shutters to "Miscellaneous Equipment" section;

All breakers will be draw-out construction; Any requirements for smaller breakers in the facilities shall use either panelboard or MCC construction. Lift Stations shall use panelboard construction, no MCCs;

PART 1 – GENERAL

16325-1.01. Scope

16325-1.02. References

16325-1.03. Submittals

16325-1.04. Quality Assurance

16325-1.05 Delivery, Storage and Handling

16325-1.06 Maintenance

PART 2 – PRODUCTS

16325-2.01. Ratings

16325-2.02. Construction

16325-2.03. Surface Preparation and Shop Coatings

16325-2.04 Shop Testing

16325-2.05. Acceptable 480-Volt Switchgear MANUFACTURERS

PART 3 – EXECUTION

16325-3.01. Installation

16325-3.02. Field Testing

16325-3.03. Adjustment

16325-3.04. Rubber Mats

16325-3.05. Cleaning

16325-3.06. Warranty

PART 1 – GENERAL**16325-1.01. Scope**

A. Furnish and install the 480VAC rear-connected switchgear (no side access) with draw-out breakers as shown on the Contract Drawings and as specified herein.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

16325-1.02. References

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:

1. ANSI/IEEE C37.13 - Low Voltage AC Power Circuit Breakers Used in Enclosures;
2. ANSI C37.16 - Preferred Ratings, Related Requirements and Application for Low Voltage Power Circuit Breakers and AC Power Circuit Protectors;
3. ANSI/IEEE C37.17 - Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers;
4. ANSI/IEEE C37.20.1 – Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear;
5. ANSI/IEEE C37.50 – Test Procedure for Low Voltage AC Power Circuit Breakers Used in Enclosures;
6. ANSI/IEEE C37.51 – Conformance Testing of Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies;
7. American Society for Testing and Materials (ASTM) D-178 - Rubber Insulating Matting;
8. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
9. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
10. NEMA SG5 - Power Switchgear Assemblies;
11. NEMA SG3 - Low Voltage Power Circuit Breakers;
12. National Fire Protection Association (NFPA) 70 – National Electric Code (NEC®);
13. NFPA 70E® - Electrical Safety in the Workplace;
14. UL 1558 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear;
15. UL 1066 - Low Voltage AC and DC Power Circuit Breakers Used in Enclosures;

B. Solid-state circuitry shall meet or exceed the Transient Overvoltage Withstand Test per NEMA ISCI-109 and the Surge Withstand Capability Tests (SWC) per IEEE Standard 472 (ANSI C37. 90A). In addition, where UL Standards exist for components, devices and/or assemblies, such standards shall apply.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

16325-1.03. Submittals

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

D. Submit shop drawings and product data for the following:

1. Equipment shop drawings showing elevation and plan views, conduit entrance spaces, nameplate data, bus arrangement, dimensions, and weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from this Section.
2. Point-to-point compartment wiring diagrams for metering, relay, and control circuits. Show wire and terminal numbers. This diagram shall include all interfaces to other control panels.
3. Product data sheets and catalog numbers for circuit breakers, trip devices and protective relays. List all options, trip adjustments and accessories furnished specifically for this project.
1. Itemized bill of materials for metering, protective relays, accessories and control equipment.
2. Instruction and renewal parts books.
3. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.
4. Certified shop test reports.
5. Field test and inspection reports.

16325-1.04. Quality Assurance

A. The Low-Voltage Switchgear MANUFACTURER shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.

B. The Low-Voltage Switchgear MANUFACTURER shall be ISO certified.

C. UL Listing Requirements -

1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
2. The Low-Voltage Switchgear shall be posted at www.UL.com under Category Code "FHCW"; Products without posting at [UL.com](http://www.UL.com) shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type "FHCW" into the Category Code search box and click Search;

D. The MANUFACTURER of the switchgear assembly shall be the same MANUFACTURER as the breakers.

E. All sections and devices shall be UL Listed and labeled.

F. Service equipment shall be UL labeled as suitable for use as service entrance equipment.

16325-1.05 Delivery, Storage and Handling

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container. Shipping groups shall not exceed 15-feet in length.

B. Circuit breakers shall be shipped inside their respective cells in which they were factory acceptance tested.

C. Store and handle in strict compliance with MANUFACTURER's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in switchgear and if necessary, apply temporary heat where required to obtain suitable service conditions.

16325-1.06 Maintenance

A. Furnish the following maintenance accessories, operating and maintenance manuals for the switchgear.

1. Manual charging handle;
2. Manual racking mechanism;
3. Breaker racking device with rail provisions installed on each draw out breaker cubicle for safe installation and removal of circuit breaker with a remote 30-foot corded operator.
4. Portable local open/close circuit breaker operator pendant with integral breaker position indication with a multi-pin 30-foot corded lockable connector. Operator pendant connector receptacle shall be installed all supplied and future circuit breaker compartments.
5. Circuit-Breaker Portable Test Set: For testing all functions of circuit breaker, solid-state trip devices without removal from switchgear;
6. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front

of switchgear, complete with hoist and lifting yokes;			
B. Provide the following spare parts in the quantities specified: 1. One dozen each of cover bolts, cage nuts and door fasteners. a. Six (6) of each type and rating of fuse used. Include spares for potential transformer fuses and control power fuses; 2. Two (2) half pint containers of paint matching enclosure finish; 3. Qty One (1) of each type frame breaker supplied ready to replace an installed breaker; 4. Spare parts shall be boxed or packaged for long-term storage and clearly identified on the exterior of the package. Identify each item with MANUFACTURERs name, description and part number.			
Item	Manufacturer	Model/Part Number	Comments
PART 2 – PRODUCTS			
16325-2.01. Ratings			
A. Service: 480VAC, 3-Phase, 3-Wire, 60-Hertz.			
B. The switchgear and protective devices shall have a fully rated, short circuit withstand rating as required by the Coordination Study. Systems employing series connected fault current limiters shall not be accepted.			
C. The continuous current rating of the bus shall be as noted in the contract documents. The bus shall be designed to carry its rated continuous current in the specified ambient temperature without exceeding the equipment temperature rise limits. Bus bracing shall exceed the specified equipment short circuit rating. Line and load bus connections to feeder devices shall be rated to carry the full continuous current of the device frame.			
D. The switchgear, including devices shall be designed for continuous operation at its rated current in a 104 °F (40 °C) ambient temperature.			
16325-2.02. Construction			
A. General:			
1. The switchgear shall be factory assembled and tested and comply with applicable industry standards. It shall be a coordinated design so that shipping groups are easily connected together at the site into a continuous line-up. Necessary connecting materials shall be furnished. All power circuit breakers and assemblies shall be produced by a single MANUFACTURER. 2. The switchgear assembly shall consist of one or more metal-enclosed sections in an indoor NEMA rated enclosure. a. End sections shall include provisions for main bus extension and installation of future vertical sections. b. The design shall incorporate preformed steel channels, angles and structural components bolted together and reinforced to form a rigid, self-supporting assembly. c. Fabricate enclosure with removable, hinged rear doors with captive screws to allow access to rear interior of switchgear. 3. Front breaker doors and covers must be free of any ventilation openings. 4. Circuit breaker compartments shall include stationary primary contact disconnects that shall be silver-plated copper at the connection points and of one-piece construction. a. The upper set of disconnects shall bolt directly to the main bus and, for feeder circuit breakers, the lower set shall extend to the rear cable area and shall be insulated where they pass through the main bus compartment. b. Primary disconnects shall be sized for the maximum continuous current for the frame size of the circuit breaker which is located in the compartment. c. Interlocks shall be provided to prevent a circuit breaker element of the incorrect frame size or interrupting rating from being inserted into the compartment. d. Secondary control and communication connections, when required, shall be located in a separately accessed area that is accessible from the front of the switchgear without opening the breaker			

compartment door or exposing any power cables or bussing. The secondary control contacts shall be of the sliding contact design, silver plated and engage the draw-out circuit breaker element in the "connected" and "test" positions.

5. All control wiring within the assembly shall be continuous and shall terminate on each end at a suitable terminal block. No splices shall be allowed. Control wiring shall be 14 AWG minimum, stranded type SIS and shall be labeled at each end with sleeve-type wire markers.
 - a. Wire markers shall be machine imprinted with the wire name as indicated on the wiring diagrams.
 - b. Terminals shall be insulated locking fork or ring tongue type except where connecting to components that do not accept these terminations. Control wiring for external connections shall be terminated in a separate front accessible compartment for ease of access.
6. Bus isolation barriers shall be arranged to isolate the buses on either side of each main and tie circuit breaker from each other.
7. Main bus shall connect vertical sections and shall be uniform capacity the entire length of assembly. Vertical and horizontal bus bar shall utilize a channel shape design to maximize short circuit withstand capability and minimize heat rise. The main horizontal bus shall be run in a vertical, edge-to-edge arrangement for high short circuit strength. Access to the rear cable termination area shall be possible without reaching over the main and vertical bus.
 - a. Bus shall be 98 % minimum conductivity copper silver-plated over entire length of the bus bar.
 - b. Feeder Circuit-Breaker Load Terminals: Plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
 - c. Ground Bus shall be copper of 98 % minimum conductivity, minimum size 1/4 by 3-inches.
 - d. Bus bracing shall be equal to the short circuit interrupting rating of the lowest rated circuit breaker applied in the assembly or 100kA minimum.
 - e. Provide for future extensions from either end of main phase, neutral and ground bus by means of predrilled bolt holes and connecting links.
8. The switchgear shall be indoor NEMA rated and include drip shields.
9. All breakers shall be mounted in draw-out construction;
10. All spaces shown on the Contract Drawings shall be completely equipped to receive a future breaker of up to 800A rating;
11. The switchgear shall consist of main-tie-main breakers and two distribution sections minimum.
12. (Lift Stations Only) Every draw out breaker compartment shall be equipped and hard wired to a centralized wiring terminal block, located in the switchgear, with the following points: "MOC" and "TOC", "A" and "B" contacts for both breaker truck position and contact position, remote open and close, breaker charged / ready to close, breaker tripped and remote reset.
13. (Treatment Facilities Only) Additional to requirements listed in 16325-2.02.12. The switchgear shall be capable of being integrated with the plant's SCADA system via PROFINET® communications. At a minimum, main breaker section 1 of the switchgear shall include an 8-port Industrial Ethernet media convertor/switch and a PROFIBUS® DP™ Transition to PROFINET® Gateway. The PROFIBUS® DP™ circuit breaker devices must be connected in a daisy chain fashion, ending with a PROFIBUS® DP™ 24vdc Powered Resistor Terminator. The gateway and the terminator must be located in the same compartment and supplied by the same voltage source feeding the Ethernet switch in the switchgear. The switchgear's communications wiring matrix layout, shall be adhere to based on OWNER's "Low Voltage (LV) Switchgear Standards under 600-volt Applications" Drawings; Each circuit breaker compartment shall be connected and ready to integrate with the plant's SCADA system via PROFINET® communications; The OWNER has standardized the automation components and they shall be as specified in Section 13310 – Programmable Logic Controller (PLC) and Digital Equipment and the OWNER's LOW VOLTAGE STANDARDS; no exceptions accepted.
14. The control power distribution automation power supplies shall be connected using transfer relays. Even if one of the power sources fails, these relays will provide the power from either source feeding the switchgear to the power supplies, only the removal of both sources will de-energize power supplies in the switchgear. Reference the OWNER's LOW VOLTAGE STANDARDS for wiring standard.

B. Structure:

1. The switchgear shall be a completely assembled unit of self-supporting construction, with voltage and current ratings as indicated on the Drawings. Each section of switchgear shall be a freestanding structure of bolted construction to rigidly support all devices and equipment. The sides shall be screw on code gauge steel plates, pan-type construction. The distribution protective devices shall be individually mounted with front-hinged cover plates and all necessary buses and straps shall be provided. Load terminals of feeder devices shall be extended to the front.
2. Protective devices shall be arranged so they are individually removable and readily interchangeable from the front of the switchgear. The breaker front shall be prominently labeled to indicate device ampere ratings and color-coded for device type. ON-OFF indication and mechanism charged/ready status shall be clearly shown on breaker front window.
3. All bus bars shall be 98 percent conductivity copper with a current density of 1,000 amperes per square inch. Surfaces shall be tin-plated by the Alstan™ 70 (or comparable) process to have a uniform appearance, free of blisters. The bus structure shall be braced to withstand the stresses of a short circuit as required at the load terminals of the feeder device, and shall be mounted on supports of high impact non-tracking insulating material. Bus bars shall be uniformly arranged to provide A-B-C sequence left to right (from front), front to rear and top to bottom. Main buses shall be rated as indicated on the contract documents.
4. A ground bus shall be provided running the full length of the switchgear, bolted to each vertical section.
5. All hardware used on conductors shall be zinc or cadmium plated, have a tensile strength of 120,000 psi.
6. The switchgear shall be provided in modular construction with adequate means for lifting, and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
7. All steel surfaces shall be chemically cleaned and treated to prevent moisture and rust under the paint film. The switchgear shall be painted with a heavy coat of ANSI No. 49 light gray enamel.

C. Circuit-Breakers

1. Circuit breakers shall comply with the requirements of IEEE/ANSI C37.13/16/17/50, UL1066, NEMA SG3. All breakers shall be three-pole, 100% rated type low voltage power breaker;
 - a. Circuit breaker element shall have connected, test and disconnected position indicators, spring charged/discharged indicators and circuit breaker open or closed and ready to close indicators all of which shall be visible to the operator with the compartment door closed. It shall be possible to rack the circuit breaker element from the connected to the disconnected position with the compartment door closed otherwise known as "through the door draw-out";
 - b. Provide interlocks to prevent racking the circuit breaker unless the breaker is open;
2. Ratings: Interrupting as required at 480VAC without fuses. Short time current ratings for each circuit breaker shall be as indicated on the Contract Drawings. Circuit breakers shall be 600VAC class.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with Normal Closing Speed: independent of both control and operator;
4. Each low voltage power circuit breaker shall be equipped with self-powered, microprocessor-based trip-device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of Rogowski coil sensors on each phase, a release mechanism and the following features:
 - a. LCD Screen, field installable and interchangeable trip unit, who can be used with any, frame size circuit breaker. Trip units to include Profibus DP communication module.
 - b. Functions: Long time, short time and extended instantaneous protection function shall be provided to allow the breaker to be applied at the withstand rating of the breaker with minus 0% tolerance so that there is no instantaneous override whatsoever. This feature shall furthermore allow the circuit breaker to be applied up to the full instantaneous rating of the breaker on systems where the available fault current exceeds the breakers withstand rating. Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I_{2t} ramp and optionally I_{4t} to improve co-ordination with fuses or inverse relays.
 - c. Field installable individual breaker zone selective interlocking modules with connections being

made between the two (2) mains, tie and feeder circuit breakers to ensure that the circuit breaker closest to the fault, trips for a short time and ground fault conditions. d. A software program shall be made available free of charge to support system coordination studies. The software will allow time current curves to be generated for the chosen settings. e. Individual LED's shall indicate an over current, short circuit or ground fault trip condition. The data shall be maintained for a minimum of 48 hours without the need for a separate battery. f. Pickup Points: 10 Long Time Settings. g. Field installable Ground fault protection with a least three (3) time delay bands. Adjustable current pickup and I²t ramp. Arranged for four- wire service. h. The option to remotely switch protection settings shall be provided whenever a generator is part of the power distribution system. i. Estimated contact wear shall be capable of being communicated remotely in addition to a local mechanical indication flag. 5. Integrated Local/Remote switch; 6. Padlocking Provisions: For installing at least three (3) padlocks on each circuit breaker to prevent movement of the draw-out mechanism. 7. Operating Handle: shall be built in complete with handle and integral to breaker. No external tools shall be required to rack the breaker 8. Modular communication and relaying accessories are to be available for retrofitting by the clients chosen Engineer. It shall not be necessary for the MANUFACTURERs personnel to retrofit accessories 9. The following items must be capable of being changed in the field: main contacts, CT's, trip units, racking mechanism and all internal & external accessories 10. Breakers shall be manufactured in accordance with NEMA SG3 and UL Listed. 11. The following accessories shall be supplied: b. Capable of being remotely electrically operated open and closed via supplied Communications specified in 16325-2.13 ; c. Capable of being monitored for voltage, amperage, open/closed status via supplied Communications as per specification:16325-2.13;	D. Metering 1. Specified main breaker units on Drawings shall be equipped with a digital-metering device capable of communication on the network of choice. The meter shall communicate directly via Ethernet to the OWNER's SCADA network. 2. See Section 16292 LOW-VOLTAGE (LV) POWER METERS for specifics
E. Miscellaneous Equipment 1. Mains and tie circuit breakers shall be furnished with solid-state ground sensors for tripping. 2. Selective tripping shall be furnished between mains, ties and feeder circuit breakers. Graphic indication of breaker coordination shall be furnished and the CONTRACTOR shall demonstrate proper coordination when complete. See Section 16050 for additional requirements. 3. Instrument Transformers: Comply with IEEE C57.13. a. Potential Transformers (PTs): Secondary-voltage rating of 120 V and NEMA accuracy class of 0.6 with burdens of W, X and Y. b. Current Transformers (CTs): Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments. 4. Provision for Future Devices: Equip future circuit-breaker compartments with rails, mounting brackets, supports, necessary appurtenances and bus connections; 5. Control Power Supply: Control power transformer supplying 120VAC control circuits through secondary disconnect devices are to be dry-type transformers with primary and secondary fuses. Transformers shall be mounted in auxiliary compartments. 6. Service Entrance Surge Protection Devices (SPD) shall be in accordance with Section 16709.	

7. Cubicle Lockable Shutter door assembly to protect from exposed energized parts of switchgear, when breaker is removed from cubicle;			
16325-2.03. Surface Preparation and Shop Coatings			
A. Steel parts shall be prepared for painting by a five-stage wash system consisting of an alkaline cleaner, fresh water rise, iron phosphate treatment, fresh water rise and non-chromate sealer. After cleaning and stabilization, the steel parts shall be coated with a thermosetting polyester powder applied with electrostatic equipment at a nominal 2 mils dry film thickness and then cured properly. The paint finish shall have a pencil hardness of 2H, a salt spray rating as defined in ASTM B-117-73 of 600 hours.			
B. All non-current carrying metal parts of the switchgear assembly shall be cleaned of all weld spatters and other foreign material and given a hot iron-phosphate chemical treatment. A Zinc rich, heat cured, epoxy primer shall be applied to inhibit rust.			
C. Indoor equipment shall be painted with one finish coat of manufacturer's standard air dried enamel. Color shall be light grey ANSI 61.			
D. Unpainted non-current carrying parts shall receive protective zinc plating to prevent corrosion. Printed circuit boards shall be coated with a protective conformal epoxy. All device contacts shall be gold or silver plated.			
16325-2.04 Shop Testing			
A. Perform MANUFACTURER's standard production testing and inspection in accordance with ANSI standards. The MANUFACTURER shall submit certified copies of test results to indicate proof of compliance with ANSI C37.50 and C37.51.			
16325-2.05. Acceptable 480-Volt Switchgear MANUFACTURERS			
A. The listing of specific MANUFACTURERS does not imply acceptance of their products that do not meet the specified ratings, features and functions. MANUFACTURERS listed are not relieved from meeting these specifications in their entirety.			
1.	EATON CORPORATION www.eaton.com 	CUTLER-HAMMER® Magnum™ DS Series Switchgear with Power Xpert 8000 with Graphic Display Module and Ethernet Communications Power Meter on each Main circuit breaker section. Magnum™ DS Draw-out Mains, Tie and distribution circuit breakers provided as per specification 16325 within. 2.02.C. SPD Series Integrated Unit shall be on main circuit breakers;	All Draw-out Breakers, Panel mounted Surge counter connected to SPD Unit ;
2.	SIEMENS INDUSTRY www.sea.siemens.com 	Type WL Low Voltage Switchgear with ACCESS™ 9340, Part No. 9340DC with Ethernet Communications Card, Part No. 9340-60-ETHER on each Main Breaker section. Draw-out Mains, Tie and distribution circuit breakers provided as per specification 16325 within. Transient Protection System TPS3 on each main circuit breaker;	All Draw-out Breakers, Panel mounted Surge counter connected to TPS3 SPD Unit;
PART 3 – EXECUTION			
16325-3.01. Installation			
A. The equipment shall be leveled and anchored directly to a concrete equipment pad or finished floor as shown on the Contract Drawings. Provide hardware and metal shims for installation. Grout and caulk all voids beneath the equipment base. Anchor bolts shall be 5/8-inch stainless steel, minimum sized and installed in accordance			

with the MANUFACTURER's recommendation.
B. Install the equipment in accordance with the MANUFACTURER's instructions.
C. Remove temporary lifting angles, lugs, and shipping braces. Touch-up damaged paint finishes.
D. Make wiring interconnections between shipping splits.
E. Install bus splice plates and torque the connections.
F. Caulk seams, cracks, and openings in outdoor enclosures.
16325-3.02. Field Testing A. A certified factory representative of the switchgear manufacturer shall inspect and test the installed equipment prior to energization. The switchgear manufacturer shall provide all material, labor, equipment and technical supervision to perform the tests and inspection.
B. Equipment testing and inspection shall be performed by an independent NETA certified testing company before energizing the switchgear in accordance with NETA Standard ATS and shall include the following: 1. Visual and mechanical inspection; 2. Ratio and polarity tests on current and voltage transformers; 3. Ground resistance test; 4. Insulation resistance tests (phase-to-phase and phase-to-ground); 5. Meter calibration; 6. Circuit breaker contact resistance test; 7. Insulation power factor and resistance test for surge arresters; 8. Phasing check; 9. Primary current injection tests on each circuit;
C. In the event of an equipment fault, notify the ENGINEER immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the CONTRACTOR, ENGINEER, OWNER and the equipment MANUFACTURER's factory service representative. Repair or replace the equipment as directed by the ENGINEER and OWNER prior to placing the equipment back into service.
16325-3.03. Adjustment A. The switchgear MANUFACTURER shall provide the services of a factory trained service representative(s) for at least 4 days. The first trip shall be coordinated with the field testing. The second trip shall include any necessary follow-up or punch list work and technical instruction for the OWNER's designated personnel. The MANUFACTURER's service representative(s) shall demonstrate all operational features of the installed switchgear.
B. The switchgear MANUFACTURER's factory service representative(s) shall make the following tests and adjustments: 1. Calibrate and test all circuit breaker trip devices, protective relays and controls per the final version of the breaker setting coordination study and provide copy of those test results and settings in the owner's operation and maintenance manual for future use; 2. Adjust and lubricate circuit breaker operating mechanisms and contacts.
16325-3.04. Rubber Mats A. Non-conductive switchboard matting is designed to provide insulation for the worker. Made from a PVC compound, the mat prevents the worker from being grounded, thereby eliminating the possibility of electrical shock. The corrugated saw-tooth top surface provides increased traction and is easy to sweep clean.
B. A three foot wide black rubber mat shall be furnished and installed on the floor and in front of each switchboard assembly. The mat shall be long enough to cover the full length of each line-up. The mat shall be ¼-inch thick with beveled edges, canvas back, and 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 for Type 2, Class 2 (30,000V) insulating matting.
16325-3.05. Cleaning A. Remove all rubbish and debris from inside and around the switchgear. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.
16325-3.06. Warranty A. Equipment MANUFACTURER warrants that all goods supplied are free of non-conformities in workmanship and materials for one (1) year from date of Substantial Completion.
END OF SECTION 16325

SECTION 16370

VARIABLE FREQUENCY DRIVES (VFD)

1.1 SCOPE

- A. The Contractor shall furnish all labor, materials, equipment and incidentals required, to complete, ready for operation and delivery, the Variable Frequency Drive (VFD) depicted on the Contract Drawings.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
 - a. See Section 16921 - Low-Voltage (LV) Motor Control Centers (MCCs) for VFDs installed in MCCs;
- C. Each VFD Control Panel shall be self-contained with all components correctly sized, based on the Owner's LIFT STATIONS STANDARDS;
- D. Contractor shall follow the application specifics of the Owner's latest and applicable standards (attached) for VFD units;
- E. Like items of equipment provided hereunder shall be the end product of one Manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts and Manufacturer's service.
- F. Any modifications to a standard VFD product required to meet this specification shall be performed by the VFD Manufacturer only. Distributor or Systems Integrator hardware field changes to the VFD Manufacturer's product are specifically disallowed.
- G. Furnish VFDs rated on basis of actual motor full load nameplate current rating and the Owner's VFD Standards HP Grouping of 1 to 20HP, 21 to 60HP, 61 to 100HP, 101 to 200HP or 201 to 400HP.
- H. 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.
- I. All components listed shall be integral to the VFD lineup, factory wired and tested as a complete system.
- J. If the Complete VFD Control Panel(s) is for one of the Owner's treatment facilities, the VFD assembly shall communicate with the plant SCADA System through PROFINET® protocol. The communication device shall be manufactured and supported by the VFD Manufacturer. No third-party communication devices shall be used. VFD supplier shall coordinate with any others involved with the project (Electrical, Instrumentation, Integrator, etc.) for specific PROFINET® requirements of the VFD and provide all necessary items, connectors for a complete working system.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. American National Standards Institute (ANSI) C62.41 - Guide for Surge Voltages in Low-Voltage AC Power Circuits;
 - 2. ANSI/ Institute of Electrical and Electronics Engineers (IEEE) 359-A-1-88 - Special Colors;
 - 3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators;
 - 4. IEEE 519 - Recommended Practices and Requirements for Harmonic Control in Electric Power Systems;
 - 5. National Electrical Manufacturer's Association (NEMA) CP 1 - Shunt Capacitors;
 - 6. NEMA MG 1 - Motors and Generators;
 - 7. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum);
 - 8. NEMA WC-57 - Control Cables;
 - 9. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 10. NEC® Article 409 – Industrial Control Panels;
 - 11. NEC® Article 430 – Motors, Motor Circuits and Controllers;
 - 12. NFPA® 70E® - Electrical Safety in the Workplace;
 - 13. NFPA® 79 - Electrical Standard for Industrial Machinery;
 - 14. Underwriters Laboratories (UL) 508 - Industrial Control Equipment;
 - 15. UL 508A – Industrial Control Equipment;
 - 16. UL 508C - Power Conversion Equipment;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the Owner:
 - 1. Overall VFD operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, and 100 percent of rated speed;
 - 2. Complete system ratings, including all nameplate data, continuous operation load capability throughout speed range of 0 to 100 percent of rated speed;

3. Complete VFD rating coordinated with motor full load nameplate current rating; list any controller special features being supplied;
 4. VFD and reactor assembly dimensional drawings; information on size and location of space for incoming and outgoing conduit. Submit verification of overall dimensions;
 5. Maximum heat dissipation from enclosure for all components furnished under this specification;
 6. Submit layout of controller face showing pushbuttons, switches, instruments, indicating lights, operator interfaces, etc.;
 7. Complete system operating description;
 8. Complete system schematic (elementary) wiring diagrams;
 9. Complete system interconnection diagrams between VFD, and isolation contactors, drive motor and all related components or controls external to system, including wire numbers and terminal board point identification;
 10. One-line diagram of system, including component ratings;
 11. Description of diagnostic features being provided;
 12. Descriptive literature for all control devices such as relays, timers, etc.;
 13. Itemized bill-of-materials listing all system components;
 14. Submit list of recommended spare parts. Include at least one full set of fuses for each VFD;
 15. Descriptive vendor literature submitted with bid documents will be accepted as reference only and will not be considered as specific submittal information and will not be evaluated for compliance with specifications;
 16. A memory map, control and status words and configuration files and data for the Profinet Interface;
 17. Complete dimensional layout of the VFD equipment room, to scale, demonstrating that proper clearances are met for all drive units to be installed as well as for future drive units;
 18. Product data sheets for all components used;
 19. Master drawing index;
 20. Cable terminal sizes;
 21. Component list;
 22. Conduit space entry/exit locations;
 23. Installation information;
- E. The drives supplier to provide typical factory test description with the project bid; VFD Systems are to be 100% tested at the factory prior to shipment; Testing shall include motor load power;
- F. VFD Systems commissioned in the field shall provide a complete startup report; The report shall include installation overview, application description, drive wiring, and parameter settings as configured for the application; Comments on drive performance as commissioned shall be noted in the field report; An electronic copy of the drive configuration shall be delivered to the Owner upon completion of the startup;

1.4 QUALITY ASSURANCE

- A. The VFD Manufacturer of this equipment shall have a minimum of ten (10)

- years consecutive experience producing similar electrical equipment.
- B. The VFD Manufacturer shall be ISO certified.
 - C. UL Listing Requirements –
 - 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 - 2. The VFD shall be posted at www.UL.com under Category Code “NMMS”. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type “NMMS” into the Category Code search box and click Search.
- 1.5 DELIVERY, STORAGE AND HANDLING
- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
 - B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
 - C. Store and handle in strict compliance with Manufacturer’s instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.
- 1.6 SPARE PARTS
- A. One (1) complete VFD Control Unit/Power Module, mounted in a reusable wooden shipping crate, of each size indicated on the Contract Drawings;
 - B. One (1) complete VFD Operator panel/keypad;
 - C. One complete set of VFD System fuses (line, load, control);
 - D. All spare parts shall be delivered prior to VFD System startup;
- 1.7 CONFIGURATION SOFTWARE AND CONNECTION CABLE
- A. One (1) complete licensed Configuration, Control and Monitoring Microsoft® Windows™ Based Software and PC to Inverter Converter & Connection Cable shall be delivered prior to VFD System startup;

PART 2 - PRODUCTS

2.1 OWNER STANDARDIZATION

- A. The Owner’s SCADA Automation Architecture is based on SIEMENS INDUSTRY Automation hardware & software components and the distributed PROFINET communications standard. Approximately two-thirds (2/3) of the Owner’s existing and installed VFDs throughout the Owner’s facilities are SIEMENS INDUSTRY or ROCKWELL AUTOMATION. The Owner has invested thousands of man-hours creating standards (control circuits, data structures, Programmable Logic Controller (PLC)/Human Machine Interface (HMI) programming objects and wiring diagrams) to facilitate the integration of field devices into our SCADA Systems. The Owner has invested hundreds of man-hours training their personnel and thousands

of dollars purchasing & stocking spare units and parts to maintain, trouble-shoot and repair these VFDs using “fully-tested” procedures and standards. The integration and development of another Manufacturer’s VFD product would vastly increase the integration efforts, maintenance costs and overall life-cycle costs for the Owner. Therefore, VFD components shall be as specified or chosen from Section 16370-2.04 or 16370-2.05 and assembled such that the intended function is achieved. In general, each VFD shall be equipped with a control unit, power module, operator panel/keypad and any additional components such as filters or reactors needed to comply with the Specifications and/or Contract Drawings.

- B. For All Complete VFD Control Panel(s), the Owner’s latest “LOW VOLTAGE STANDARDS” (attached) shall be followed.

2.2 RATINGS

- A. VFD(s) shall meet or exceed the ratings listed below, at a minimum:
 - 1. 1.3 to 477A; ½ to 400 HP (0.37kW to 250kW) VFD power range;
 - 2. 380- to 480VAC, +/-10%, three-phase rated input voltage;
 - 3. 47- to 63-Hertz rated frequency;
 - 4. 0.7 to .85 rated power factor;
 - 5. 95% inverter efficiency;
 - 6. High overload capability for 1.3 to 145A; ½ to 100 HP (0.37 to 75kW):
 - a. 1.5-times rated output current (150% overload) for 57-seconds with a cycle time of 300-seconds;
 - b. 2-times rated output current (200% overload) for 3-seconds with a cycle time of 300-seconds;
 - 7. High overload capability for 178 to 477A; 125 HP to 400 HP (90 to 200kW):
 - a. 1.36-times rated output current (136% overload) for 57 seconds with a cycle time of 300 seconds;
 - b. 1.6-times rated output current (160% overload) for 3 seconds with a cycle time of 300 seconds;
 - 8. NEMA 1 degree of enclosure protection;
 - 9. Operating temperature: 32 to 104 °F (0 to 40 °C) without derating;
 - 10. Storage temperature: -40 to 158 °F (-40 to 70 °C);
 - 11. Relative Humidity: <95% RH, non-condensing;
 - 12. Standard Protection Functions included: Under voltage, Over voltage, Over control/overload, Ground fault, Short circuit, Stall protection, Motor blocking protection, Motor over temperature, Inverter over temperature and Parameter locking;
 - 13. VFD product family shall be available in different mechanical sizes;
 - 14. UL Listing;
- B. VFD(s) shall be Modular;
 - 1. VFD modularity ensures flexibility for the future;
 - 2. VFD shall have pluggable terminals;
 - 3. VFD modules can be easily replaced, which makes the VFD extremely service friendly;

4. The VFD shall be comprised of a variety of modular functional units (control unit, memory card, power module, operator keypad, filter, reactor, etc.);
- C. VFD(s) Power Module (PM) supplies the motor in a power range of 1.3 to 477A; ½ to 400 HP (0.37 to 250kW);
 1. The PM is controlled by a microprocessor;
 2. State-of-the-art IGBT technology with six (6) pulse-width modulation (PWM) used to achieve the highest degree of reliability and flexible motor operation;
 3. The VFD shall use solid state electronics with a PWM output and the following:
 - a. VFD shall have the capability of kinetic buffering that allows the VFD to “ride through” power dips without a controller trip depending on load and operating conditions;
 - b. VFD shall have an electronic overload circuit designed to protect an AC motor operated by the VFD (this electronic overload shall be UL and NEC® recognized as adequate motor protection);
 - c. The VFD shall include the following protective circuits:
 - i. Phase to Ground short circuit condition;
 - ii. Output phase-to-phase short circuit condition;
 - iii. Total ground fault under any operating condition;
 - iv. High input line voltage;
 - v. Low input line voltage;
 - vi. Loss of input or output phase;
 - vii. External fault;
 - d. VFD shall not require additional hardware such as motor overload relays or motor thermostats to protect an AC motor;
 - e. VFD shall have a removable operator panel (keypad) that can be programmed to display any analog value within the drive.
 - f. VFD shall have 16 programmable fixed frequencies and 4 programmable skip frequencies;
- D. VFD(s) Control Unit (CU) controls and monitors the PM and the connected motor using several different selectable control strategies;
 1. CU shall be powered via the PM or an external 24VDC source;
 2. CU shall have open-loop/closed-loop control techniques - voltage/frequency (V/f) linear/square/parameter, V/f with flux current control, Vector control with or without encoder, Torque control with or without encoder;
 3. CU shall include, as a minimum, six isolated discrete inputs, two scalable analog inputs (voltage or current), two analog outputs (voltage or current), three relay outputs and an encoder for speed feedback, all fully programmable;
 4. CU shall be capable of minor firmware upgrades using a local memory device;
 5. CU shall have a PID regulator for set point control;
 6. CU shall have the following internal functions available:
 - a. Arithmetic - Add, Subtract, Multiply, Divide and Compare;
 - b. Logic - AND, OR, XOR, NOT, Flip-Flop;

- c. Timers;
- 7. The CU shall support communications, local and network, as an option (PROFINET™);
- E. VFD(s) Additional Components (a.k.a. Options) shall be provided, as required:
 - 1. Operator panel/keypads – connected directly to the CU; remotely mounted, or handheld for mobility;
 - 2. Line filters a.k.a. radio frequency interference (RFI) / electro-magnetic interference (EMI) filters – used to prevent interference with other sensitive electronic loads by reducing inverter emissions;
 - 3. Line reactors – used to reduce the system perturbations caused by harmonics;
 - 4. Braking resistors – used to dissipate excess energy in the DC link by use of an electronic switch (chopper);
 - 5. Sine-wave filters – used to limit the rate of rise of voltage and the capacitive charging/discharging currents that usually occur with VFD operation (an output reactor is not required);
 - 6. Output reactors – used to reduce the voltage stress on the motor windings; At the same time, the capacitive charging & discharging currents, which place an additional load on the PM when long motor cables are used, are reduced;
- F. All Complete VFD Control Panel(s) in this project shall be provided with surge protection as specified in Section 16709 - Protectors and Surge Protection Devices (SPDs).
- G. All Complete VFD Control Panel(s) in this project shall be provided in enclosures as specified on the Contract Drawings or as follows:
 - 1. Indoors – NEMA 250, Type 12 with gasket, freestanding, enclosure for floor mounting, completely front accessible only and hinged doors. Properly sized to dissipate heat (even when assemblies are placed side-by-side with no gap between them) generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure shall be able to be tilted sideways to enter electrical room. VFD supplier shall verify before bidding space requirements of all VFD and possible active filtering equipment in electrical room. Coordinate any room layout modifications with Contractor before bidding.
 - 2. Outdoors – NEMA 250, Type 4X 316 stainless steel with gasket, freestanding, enclosure for floor mounting, completely front accessible only and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Provide additional cooling with a panel mounted air-conditioning unit. AC Unit shall be sized to maintain maximum inside temperature of 80 °F (27 °C). All external components shall be non-corrosive Type 316 stainless steel. Maintain NEMA 4X integrity of enclosure when mounting the cooling device.
 - 3. Furnish drive complete with compartment door interlocked with main circuit breaker (defeatable) and lockable in the open position,

alphanumeric keypad and display, and operator's controls. VFD system shall have a UL label and ISO9001 certification.

4. Size forced-ventilation (front only) for continuous operation to cool each unit with maximum room ambient temperature of 95 degrees F.
 5. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding; label each terminal for permanent identification of leads; identify each wire at each end with imprinted Mylar adhesive-back wire markers; incorporate in as-installed wiring diagrams for wire and terminal numbers shown; wiring across door hinges use 19-strand, NEMA WC-57 Class C stranding looped for proper twist rather than bending at hinge; wire connections internal to panels by crimp-on terminal types. For multiple enclosure systems, complete interconnection wiring with enclosure openings with gaskets for wiring; multipoint plug receptacles for any control wiring crossing equipment shipping splits.
 6. Drives shall fit within dimensions indicated. Maximum dimensions shall be as indicated on Contract Drawings.
- H. The Owner has grouped, by cost, frame size and amperage, Acceptable Manufacturers product offerings in an effort to reduce spares;

ALLEN-BRADLEY® PowerFlex® 700	SIEMENS SINAMICS G120
34A; ½ to 20 HP (0.37 to 15kW); 2;	32A; ½ to 20 HP (0.37 to 15kW); FSC;
96A; 21 to 60 HP (16 to 45kW); 5;	90A; 21 to 60 HP (16 to 45kW); FSE;
156A; 61 to 100 HP (46 to 75kW); 6;	145A; 61 to 100 HP (46 to 75kW); FSF;
248A; 101 to 200 HP (76 to 132kW); 6;	250A; 101 to 200 HP (76 to 132kW); FSF;
481A; 201 to 400 HP (133 to 250kW); 8;	477A; 201 to 400 HP (133 to 250kW);
	FSGX;

PowerFlex® 700 Mechanical W x H x D inches (mm); lbs. (kg)

0 – 4.33 x 13.23 x 7.87 (110 x 336 x 200); 11.5 (5.22)
2 – 8.74 x 13.48 x 7.87 (222 x 342.5 x 200); 27.6 (12.52);
3 – 8.74 x 20.37 x 7.87 (222 x 517.5 x 200); 40.9 (18.55);
5 – 12.16 x 25.37 x 10.84 (308.9 x 644.5 x 275.4); 82 (37.19);
6 – 15.90 x 33.46 x 10.85 (403.9 x 850 x 275.5); 157.5 (71.44);
7 – 59 x 20.25 x 16.02 (1498.6 x 514.4 x 406.9); 375 (170);
8 – 93.46 x 29.83 x 35 (2373.9 x 757.7 x 889); 1122 (509);

SINAMICS G120 Mechanical W x H x D inches (mm); lbs. (kg)

FSB – 6.02 x 10.63 x 9.06 (153 x 270 x 230); 8.82 (4);
FSC – 7.44 x 13.15 x 9.84 (189 x 334 x 250); 15.43 (7);
FSD – 10.83 x 16.50 x 10.24 (275 x 419 x 260); 28.66 (13);
FSE – 10.83 x 19.65 x 10.24 (275 x 499 x 260); 35.27 (16);
FSF – 13.78 x 24.96 x 14.65 (350 x 634 x 372); 85.98 (39);
FSGX – 12.90 x 60.35 x 21.60 (326 x 1533 x 547); 383.60 (174);

2.3 ACCEPTABLE MANUFACTURERS

- A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions.

Manufacturers listed are not relieved from meeting these specifications in their entirety.

- B. All Complete Control Panel VFDs in this project shall be provided by the same Supplier as all electrical equipment. This Division 16 Electrical Supplier shall coordinate with the Division 11 Equipment Supplier(s) to ensure proper sizing, space, connections, terminating lugs, conduit entry requirements, cable, etc. The Electrical Supplier and the Division 11 Equipment Supplier(s) are required to provide written evidence of this “complete” coordination in their respective submittals. Submittals without this coordination shall be rejected.
- C. ~~All VFD's in this project shall be of the same Manufacturer and represented by their local factory-certified VFD Product Partner.~~
- C. **All VFDs in this project shall be of the same Manufacturer and represented by their local factory-certified VFD Product Partner by Square D, Eaton, Allen Bradley or Siemens.**
- D. **Part numbers and model numbers included in this specification are provided for reference only to determine contract requirements, provide latest models of equivalent products as required.**

2.4 ROCKWELL AUTOMATION ALLEN-BRADLEY® POWERFLEX® 700

- A. Control/Power Unit:
480VAC ±10%; Up to 481A (400 HP); 3Ø, 60-Hertz;
Flange Mount (Front: IP00, NEMA/UL Type Open; Back/Heat sink: IP54, NEMA/UL Type 12);
Standard I/O comprised of 6 Discrete Inputs, 3 Discrete Outputs, 2 Analog Inputs, 2 Analog Outputs and 1 Encoder Input;
 - 1. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 034 N0ANNNNC0;
 - 2. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 096 N0ANNNNC0;
 - 3. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 156 N0ANNNNC0;
 - 4. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 248 N0ANNNNC0;
 - 5. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 481 N0ANNNNC0;
- B. Operator Panel/Keypad
 - 1. ROCKWELL AUTOMATION
www.ab.com
Part No. 20-HIM-A6 with HAND/AUTO Pushbutton;

- Human Interface Module (HIM) for Remote (Panel Mount) IP66, NEMA/UL Type 4x/12 for Indoor Use only, includes a 1202-C30 interface cable (3 meters);
- C. Configuration, Control and Monitoring Microsoft® Windows™ Based Software, PC To Inverter Converter & Connection Cable
 - 1. ROCKWELL AUTOMATION
www.ab.com
 Part No. 9306-4EXP02ENE and
 Part No. 1203-USB;
 DriveExplorer™ for PC full feature version and Universal Serial Bus™ Converter;
 - D. 5% IP11 Heavy Duty Line Reactor
 - 1. ROCKWELL AUTOMATION
www.ab.com
 Part No. 1321-3RA...;
 - E. 5% IP11 Heavy Duty Output Reactor
 - 1. ROCKWELL AUTOMATION
www.ab.com
 Part No. 1321-3RA...;
- 2.5 SIEMENS INDUSTRY SINAMICS G120 STANDARD INVERTER
- A. Control Unit (CU):
 Standard I/O comprised of 9 Discrete Inputs, 3 Discrete Outputs, 2 Analog Inputs, 2 Analog Outputs and 1 Encoder Input;
 RS232 (CU240S, -PN or -DP);
 IP20;
 - 1. SIEMENS INDUSTRY
www.sea.siemens.com
 Part No. 6SL3 244-0BB12-1BA1,
 Part No. 6SL3 254-0AM00-0AA0;
 LIFT STATION STANDARD G120 CU240E-2,
 Memory Card;
 - 2. SIEMENS INDUSTRY
www.sea.siemens.com
 Part No. not released yet;
 Part No. 6SL3 254-0AM00-0AA0;
 PROFINET® STANDARD
 G120 CU240E-2 with PROFINET®,
 Memory Card;
 - B. Power Module (PM)
 380... 480VAC ±10%; Up to 477A (400 HP); 3ø, 60-Hertz;
 IP20;
 - 1. SIEMENS INDUSTRY
www.sea.siemens.com
 Part No. 6SL3 224-0BE31-1UA0;
 - 2. SIEMENS INDUSTRY
www.sea.siemens.com
 Part No. 6SL3 224-0BE33-7UA0;

3. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE35-5UA0;
4. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE41-1UA0;
5. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0XE42-0UA0;
- C. Operator Panel/Keypad
 1. SIEMENS INDUSTRY
www.sea.siemens.com
KNORRTEC
www.knorrtec.de
Part No. 6SL3 255-0AA00-4CA1 with HAND/AUTO Pushbutton;
Part No. 6SL3 256-0AP00-0JA0;
KNORRTEC Part No. 10045200; and
KNORRTEC Part No. 2382566;
- D. Configuration, Control and Monitoring Microsoft® Windows™ Based Software and PC to Inverter Connection Cable Kits
 1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 255-0AA00-2CA0;
 2. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 255-0AA00-2AA1;
- E. Line Reactor
 1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 ...;
- F. Output Reactor
 1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6S ...;

PART 3 - INSTALLATION

3.1 DELIVERY

- A. Upon delivery, the Contractor shall coordinate with the VFD Manufacturer or their local factory-certified VFD Product Partner to ensure a correct mechanical and electrical installation of the VFD and associated components.

3.2 INSTALLATION

- A. The VFD Manufacturer shall have the local capability and personnel to assist in the start-up, training, service and maintenance of the VFD(s).
- B. All VFD Control Panel(s) shall be installed per the Contract Drawings in accordance with the Manufacturer's recommendations.

- C. Remove temporary lifting angles, lugs, and shipping braces.
- D. The VFD Control Panel(s) shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by Manufacturer.
- E. The Contractor shall provide the technical services of the VFD Manufacturer or their local factory-certified VFD Product Partner, who shall supervise the installation, perform a certified VFD startup and testing of each VFD Control Panel(s) and accessories furnished under this Section and instruct the Owner's personnel in the correct operation of the VFD units.
- F. All costs for transportation, lodging, subsistence, and other incidental costs for the VFD Manufacturer or their local factory-certified VFD Product Partner personnel during the installation, startup, testing, and instruction shall be by the Contractor at no cost to the Owner.
- G. The Contractor shall install all VFD Control Panels in accordance with Manufacturer's installation instructions and the Contract Drawings. All panels shall be installed plumb vertically and horizontally within one degree.

3.3 ADJUSTING AND CLEANING

- A. The VFD Control Panel(s) shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.4 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.5 STARTUP SERVICES

- A. The Contractor shall provide the following VFD Manufacturer or their local factory-certified VFD Product Partner Services, at a minimum:
 - 1. Two (2) person-days (a day equals 8-hours) for installation assistance and inspection;
 - 2. Two (2) person-days for functional and performance testing and completion of VFD Manufacturer Certified VFD Startup and Certificate of Proper Installation;
 - 3. One (1) person-day for facility startup (Two (2) additional trips shall be included for this work at days/times approved and selected by the Owner);
- B. The initial Manufacturer Certified VFD Startup of each VFD delivered with the assistance of the Owner shall include the following, at a minimum:
 - 1. Verify that the model numbers and the voltage ratings are as specified in the purchase order or Contract Drawings by matching the nameplate data for each VFD to the purchase order or Contract Drawings;
 - 2. Verify that the VFD has been installed in accordance with the mechanical and electrical installation sections of the O&M Manual;
 - 3. Inspect the security of the supply line power, ground connections, and all control circuit connections;

4. Review the “as wired” schematic and determine where the motor “safety circuit” is connected;
5. Verify that the emergency contacts are properly terminated in the VFD’s safety shutdown circuit;
6. Verify that all other field-installed wires are correctly terminated (including the shields);
7. Record the motor nameplate (voltage, power factor, full load amps, RPM, etc.) information;
8. Verify that the input voltage matches the VFD’s rating;
9. Verify that the motor is wired for the application voltage;
10. Record any other connections to the VFD by terminal number to determine if special configuration or programming is required;
11. Off-line, verify that the configuration is ready to perform adequately for start, stop and speed command functions;
12. Apply power to the VFD;
13. Make sure that the input voltage is correct for the system being set up;
14. Verify that the VFD display is on;
15. Download configuration;
16. Proceed with commissioning procedure;
17. Verify that the direction of motor rotation is correct;
18. Verify correct operation in HAND/LOCAL, OFF and AUTO/REMOTE modes;
19. Upload installed VFD configuration and provide a copy of the file to the Owner;
20. Manufacturer certified start-up form shall be filled out for each VFD started up with a copy provided to the Owner.

3.6 ON-SITE TRAINING

- A. The VFD Manufacturer or their local factory-certified VFD Product Partner shall provide on-site training;
 1. Minimum of four (4) hours of on-site training per each VFD supplied at time(s) and location(s) approved by the Owner;
 2. Each student shall receive a “quick startup guide”, a listing of each VFD(s) switch configuration and parameterization and Trouble-shooting guide with Fault codes;
 3. Any and all special tools, equipment training manuals used during the training shall be the property of the Owner upon completion of the training.

3.7 WARRANTY

- A. Any VFD(s) or components that fail or perform incorrectly prior to warranty completion shall be replaced at no cost to the Owner.
- B. The factory warranty shall include all parts related to the restoration of the failed component.
- C. VFD Manufacturer shall guarantee the VFD and supporting components with a factory warranty to be free of defects in materials and workmanship for a period of two-years from date of Substantial Completion.

VFD PARAMETER SETUP CHECKLIST

[ENTER NAME OF FACILITY]

☐ 1. Ramp up speed	_____
☐ 2. Ramp down speed	_____
☐ 3. Min speed (Hz)	_____
☐ 4. Max speed (Hz)	_____
☐ 5. 4-20mA setting at min speed (mA)	_____
☐ 6. 4-20mA setting at max speed (mA)	_____
☐ 7. Output scale calibration	_____
☐ 8. Auto restart after power failure (yes/no)	_____
☐ 9. Auto restart after overcurrent fault (yes/no)	_____
☐ 10. Speed reference (internal/external)	_____
☐ 11. If external - signal source	_____
☐ 12. If external - signal type	_____
☐ 13. Restart after E-Stop (yes/no)	_____
☐ 14. Discrete outputs - Run (yes/no)	_____
☐ 15. Discrete outputs - Fault (yes/no)	_____
☐ 16. Analog outputs - Amps (absolute units)	_____
☐ 17. Analog outputs - KW (absolute units)	_____
☐ 18. Analog outputs - Speed (Hz)	_____
☐ 19. Analog outputs - Speed (RPM)	_____
☐ 20. Analog inputs - 4mA set to 0Hz (yes/no)	_____
☐ 21. Analog inputs - 20mA set to 60Hz (yes/no)	_____
☐ 22. Analog inputs - min speed limit set (yes/no)	_____
☐ 23. Analog inputs - max speed limit set (yes/no)	_____
☐ 24. Voltage boost (%)	_____
☐ 25. Starting frequency (Hz)	_____
☐ 26. PMW carrier frequency (Hz)	_____
☐ 27. Acceleration time (sec)	_____
☐ 28. Deceleration time (sec)	_____
☐ 29. Forward run (yes/no)	_____
☐ 30. Reverse run (yes/no)	_____
☐ 31. Overload (60%-100%)	_____

VFD PARAMETER SETUP VERIFICATION

[ENTER NAME OF FACILITY]

Date: _____

General Contractor: _____

Electrical Subcontractor: _____

VFD Supplier: _____

This certifies that the VFD parameters have been coordinated per the specifications and the requirements of Section 16370.

(Authorized Representative of the General Contractor)

Date

(Authorized Representative of the Electrical Subcontractor)

Date

(Authorized Representative of the VFD Supplier)

Date

END OF SECTION

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GROUNDING SYSTEM

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes materials, testing, and installation of electrical grounding.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
- C. All work shall be performed according to National Fire Prevention Association® (NFPA®) 780, National Electrical Code® (NEC®) Article 250, City's Lift Stations Standards Detail Sheets 902-908 and the City's Low Voltage Standards Detail Sheets 902-908;
- D. Do not energize the electrical power system unless the system ground resistance is equal to or less than five (5) ohms.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. American Society for Testing and Materials (ASTM) B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;
 - 2. ASTM B-33 Tinned Soft or Annealed Copper Wire;
 - 3. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems;
 - 4. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 5. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 6. NECA 331 - Standard for Building and Service Entrance Grounding and Bonding;
 - 7. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 8. NEC® Article 250 – Grounding and Bonding;
 - 9. NFPA® 70E® - Electrical Safety in the Workplace;
 - 10. Underwriters Laboratories (UL) 467 - Grounding and Bonding Equipment;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 - 1. Descriptive bulletins;
 - 2. Product data sheets;
 - 3. Master drawing index;
 - 4. Dimensioned front & plan view of the assembly;
 - 5. Schematic diagram;
 - 6. Cable terminal sizes;
 - 7. Component list;
 - 8. Conduit space entry/exit locations;
 - 9. Ratings;
 - 10. Wiring diagrams;
 - 11. Installation information;
- E. Submit material list for all grounding materials and equipment. Indicate size, material and Manufacturer;
- F. Submit resistance reading for each ground rod;

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements
 - 1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
 - 2. The Grounding components shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a

manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.

- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GROUND RODS

- A. All grounds rods shall be 10-mil Copper plated steel, 3/4-inch diameter, minimum 20-feet long with hardened steel points;
- B. All grounds rods shall be UL Listed;
- C. Acceptable Ground Rod Manufacturers
 - 1. ERICO® PRODUCTS INC.
www.erico.com
 Sectional Copperbonded Ground Rods,
 Part No. 633400;
 with Threaded Coupler,
 Part No. CR34;
 - 2. HARGER LIGHTNING & GROUNDING
www.harger.com
 Copper Clad Steel Ground Rods, Part No. 3410;
 with Coupler,
 Part No. GRCC34;
 - 3. THOMPSON LIGHTNING PROTECTION, INC.
www.tlpinc.com
 Sectional Copperclad,
 Part No. TL3410S;
 with Coupler,
 Part No. 70C;

2.2 BARE TINNED CONDUCTORS

- A. Bare Copper wire shall not be used;
- B. Conductors shall meet ASTM B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; B-33 Tinned Soft or Annealed Copper Wire;
- C. Bare #2-Tinned, 7-Strand Conductors
- D. Acceptable Bare Tinned Conductor Manufacturers
 - 1. HARGER LIGHTNING & GROUNDING
www.harger.com
 7 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
 Part No. 2-7T;
 - 2. NEHRING ELECTRICAL WORKS CO.
www.nehringwire.com

- Stranded/Concentric Bare Tinned Copper;
- E. Bare #2/0-Tinned, 19-Strand Conductors
- F. Acceptable Bare #2/0-Tinned, 19-Strand Conductor Manufacturers
 - 1. HARGER LIGHTNING & GROUNDING
www.harger.com
19 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
Part No. 2/0-19T;
 - 2. NEHRING ELECTRICAL WORKS CO.
www.nehringwire.com
Stranded/Concentric Bare Tinned Copper;
- G. Bare #4/0-Tinned, 19-Strand Conductors
- H. Acceptable Bare #4/0-Tinned, 19-Strand Conductor Manufacturers
 - 1. HARGER LIGHTNING & GROUNDING
www.harger.com
19 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
Part No. 4/0-19T;
 - 2. NEHRING ELECTRICAL WORKS CO.
www.nehringwire.com
Stranded/Concentric Bare Tinned Copper;
- I. Bare Tinned Bonding Jumper Braid
 - 1. Tinned copper braided tape, constructed of 30-gauge bare copper
wires, #4 AWG unless noted to be #2 or #1/0;
 - 2. Terminate with flat two-hole lug;
- J. Acceptable Bare Tinned Bonding Jumper Braid Manufacturers
 - 1. BURNDY®
www.burndy.com
Un-insulated Copper Braid;
 - 2. HARGER LIGHTNING & GROUNDING
www.harger.com
Tinned Copper Flat-Braid Conductor,
Part No. CUFBxxxxxT;
- K. Bare Tinned Flexible Jumper Strap
 - 1. Tinned flexible fat conductor, 480 strands of 30-gauge bare copper
wires, 3/4-inch wide, 9-1/2-inch long, 48.250 circular mil;
 - 2. Select braid with holes sized for 3/8-inch diameter bolts and protect the
braid with copper bolt-hole ends; Terminate with flat two-hole lug;
- L. Acceptable Bare Tinned Flexible Jumper Strap Manufacturers
 - 1. BURNDY®
www.burndy.com
Grounding Products;
 - 2. HARGER LIGHTNING & GROUNDING
www.harger.com
Tinned Copper Flat-Strap Conductor,
Part No. CUFSxxxxxT;

2.3 CONNECTORS

- A. Connect grounding conductors with connectors using the exothermic

reaction where feasible, otherwise use mechanical type connector, split-bolt, saddle or cone screw type, copper alloy material;

- B. Exothermic Weld Ground Rod Clamps
- C. Acceptable Exothermic Weld Ground Rod Clamp Manufacturers
 - 1. BURNDY®
www.burndy.com
BURNDYWeld®;
 - 2. ERICO® PRODUCTS INC.
www.erico.com
CADWELD® Electrical Grounding and Bonding;
 - 3. HARGER LIGHTNING & GROUNDING
www.harger.com
Ultraweld®;
- D. Disconnecting Ground Rod Clamps
 - 1. Cast bronze with at least two stainless steel bolts;
- E. Acceptable Disconnecting Ground Rod Clamp Manufacturers
 - 1. HARGER LIGHTNING & GROUNDING
www.harger.com
Ground Rod Clamp,
Part No. 302;
 - 2. INDEPENDENT PROTECTION CO., INC.
www.ipclp.com
Ground Rod Clamp,
Part No. 52A;

2.4 GROUND WELL WITH COVER

- A. For use in non-vehicular traffic situations only; Not for installation in concrete or asphalt; "GROUND" embossed on cover; Approx. 13-inch x 24-inch x 18-inch Deep;
- B. Acceptable Ground Well with Cover Manufacturers
 - 1. ERICO® PRODUCTS INC.
www.erico.com
Polymer Concrete Inspection Well, Part No. T416A;
 - 2. HARGER LIGHTNING & GROUNDING
www.harger.com
Polymer Concrete Inspection Well, Part No. GAW132418HD;

2.5 GROUNDING MISCELLANEOUS MATERIALS

- A. For other components not specified, yet needed;
- B. Acceptable Grounding Miscellaneous Materials Manufacturers
 - 1. ERICO® PRODUCTS INC.
www.erico.com
ERITECH® Grounding Products;
 - 2. HARGER LIGHTNING & GROUNDING
www.harger.com
Grounding & Bonding Products;

PART 3 - EXECUTION

3.1 GROUNDING ELECTRODE SYSTEM

- A. Bond the following together to form the grounding electrode system:
 - 1. The ground rod and counterpoise installation;
 - 2. All existing ground conductor installations;
 - 3. All enclosures;
 - 4. The ground ring (counterpoise) encircling the light pole;
 - 5. The fence surrounding the area;
 - 6. Concrete encased re-bar;

3.2 MAIN SYSTEM GROUND REQUIREMENTS

- A. Install a ground conductor from the main distribution panel or switchboard to the grounding electrode system.
- B. Provide ground rod installation and make exothermic connections at all pad-mounted transformers, pad-mounted switches, manholes, handholds and light poles.

3.3 EQUIPMENT GROUNDING METHODS

- A. Install a separate ground conductor in all raceways. This separate ground conductor is in addition to the shield, drain and ground wires of multi-conductor cables for power, control, instrumentation and telemetry.
- B. At all electrical equipment, install insulated throat grounding bushings on all conduits and a lug on the panel back box and bond conduits and back box together using a #4 AWG minimum copper conductor. Bond junction boxes in feeder conduit runs in a similar manner.
- C. At outlet, junction and pull boxes, install a grounding jumper from box ground screw to equipment or device ground terminal.

3.4 SPECIAL SYSTEM GROUNDING

- A. For telephone, alarm, and communication systems provide a #4 AWG minimum copper conductor from the grounding electrode system to each terminal cabinet or equipment location;

3.5 DRY-TYPE TRANSFORMER GROUNDING

- A. Ground the neutral of each dry-type transformer to the grounding electrode system using a separate conductor, size #2/0 AWG or larger.

3.6 GROUND TEST WELL

- A. Provide a handhold and ground rod test well to aid in performing ground testing and connecting additional depth of ground rods if required by the test results.
 - 1. Connect ground wire from ground rod to main service switchboard ground bus.
 - 2. Test wells to be located at all installations where a counterpoise is installed, and also as shown on the drawings.

3.7 GROUND WIRE INSTALLATION

- A. Provide and install Bare Tinned Copper Conductor for all underground wire.

3.8 TESTS

- A. Before making connections to the ground electrodes, measure the resistance of each electrode to ground using a ground resistance tester. Perform the test not less than two days after the most recent rainfall, and in the afternoon after any ground condensation (dew) has evaporated.
- B. After all individual ground electrode readings have been made, interconnect as required and measure the system's ground resistance.
- C. Record and submit all measured values to City.
- D. Do not energize the electrical power system unless the system ground resistance is less than 5 ohms.

3.9 WARRANTY

- A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

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Section 16500

LIGHTING SYSTEM

PART 1 - GENERAL

1.1 SCOPE

- A. Furnish and install complete lighting systems including panelboards, transformers, lighting fixtures, receptacles, switches, contactors, and all necessary accessories and appurtenances required as herein specified and shown on the Contract Drawings.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
 - a. Section 16010 - Electrical – General Provisions
 - b. Section 16050 - Basic Electrical Materials and Methods;
 - c. Section 16108 – Miscellaneous Equipment;
 - d. Section 16110 - Raceways, Boxes and Fittings for conduit;
 - e. Section 16120 - Wires and Cables – 600-Volt and Less;
 - f. Section 16160 – Panelboards;
 - g. Section 16190 - Supporting Devices;
 - h. Section 16450 - Grounding System;
 - i. Section 16670 - Lightning Protection System (LPS);
 - j. Section 16709 - Protectors and Surge Protection Devices (SPDs);
 - k. Section 16950 - Electrical Testing;
- C. All lighting fixtures shall be in accordance with the NEC® and be constructed in accordance with UL 1598 latest edition;
- D. All fixtures and devices shall be UL Listed and labeled;
- E. All luminaries shall be manufactured by the same Manufacturer, no exceptions;
- F. The City has specified light-emitting diode (LED) lighting (4000K to 5000K) systems for environmental (mercury-free products, reduce carbon emissions, etc.) & economical (reduce lighting energy costs by as much as 80% and drastically reduce lighting maintenance costs) reasons.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

2. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
3. NECA 500 - Standard for Installing Indoor Lighting Systems;
4. NECA 501 - Standard for Installing Exterior Lighting Systems;
5. NECA 502 - Standard for Installing Industrial Lighting Systems;
6. NECA 505 - Standard for Installing and Maintaining High Mast, Roadway and Area Lighting;
7. National Electrical Manufacturers Association (NEMA) WD 1 - General Color Requirements for Wiring Devices;
8. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
9. NEMA WD 6 - Wiring Devices—Dimensional Specifications;
10. NFPA® 70E® - Electrical Safety in the Workplace;
11. Underwriters Laboratories (UL) 20 - General-Use Snap Switches;
12. UL 66 - Fixture Wire;
13. UL 542 - Lamp holders, Starters, and Starter Holders for Fluorescent Lamps;
14. UL 773 – Plug-In Locking Type Photo-controls for Use with Area Lighting;
15. UL 773A - Nonindustrial Photoelectric Switches for Lighting Control;
16. UL 844 - Luminaries for Use in Hazardous (Classified) Locations;
17. UL 924 - Emergency Lighting and Power Equipment;
18. UL 935 - Fluorescent Lamp Ballasts;
19. UL 1029 - High-Intensity-Discharge Lamp Ballasts;
20. UL 1570 – Fluorescent Lighting Fixtures;
21. UL 1572 – High Intensity Discharge Lighting Fixtures;
22. UL 1598 - Luminaries;
23. UL 1598C – Light Emitting Diode (LED) Retrofit Luminaire Conversion Kits;
24. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. The following information, at a minimum, shall be submitted to the City:
 1. Descriptive bulletins;

2. Product data sheets;
3. Master drawing index;
4. Dimensioned front & plan view of the assembly;
5. Schematic diagram;
6. Cable terminal sizes;
7. Component list;
8. Conduit space entry/exit locations;
9. Ratings;
10. Wiring diagrams;
11. Installation information;

1.4 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements
 1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
 2. The Lighting products shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SPARE PARTS

- A. Spare lamps shall be provided for all fixture types, except LED, supplied. The quantity of each type of lamp shall be 15% of the total used on the project, with a minimum of two;

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. The listing of specific Manufacturers does not imply acceptance of their

products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.2 WALL SWITCHES

- A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.49. Wall Switches for specifics;

2.3 STRAIGHT-BLADE RECEPTACLES

- A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.50. Straight-Blade Receptacles for specifics;

2.4 DEVICE PLATES

- A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.51. Device Plates for specifics;

2.5 INTERIOR/EXTERIOR INDUSTRIAL BULKHEAD AREA LUMINARIES

- A. Features include:
 1. Low power consumption;
 2. Instant on/off response;
 3. Weather/corrosion resistant lamp assembly and housing;
 4. 120/277VAC, 60-Hertz;
 5. Resistant to shock and vibration;
 6. 5-Year Warranty;
 7. 70% lumen maintenance over 60,000 operating hours;
 8. NEMA 4X (IP66);
 9. UL1598;
- B. Acceptable Interior/Exterior Industrial Bulkhead Area Luminaire Manufacturers;
 1. DIALIGHT CORPORATION
www.dialight.com
 DuroSite™ STW Series LED Wallpack / Area Light Fixtures;
 Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments;
 2. City Preapproved Equal

2.6 INTERIOR/EXTERIOR INDUSTRIAL DOWN-LIGHT AREA LUMINARIES

- A. Features include:
 1. Low power consumption;
 2. Instant on/off response;
 3. Weather/corrosion resistant lamp assembly and housing;
 4. 120/277VAC, 60-Hertz;
 5. Resistant to shock and vibration;
 6. 5-Year Warranty;
 7. 70% lumen maintenance over 100,000 operating hours;
 8. UL1598;
 9. Operating Temp: -40°F to +149°F (-40°C to +65°C)

- B. Acceptable Interior/Exterior Industrial Down-light Area Luminaire Manufacturers
 - 1. DIALIGHT CORPORATION
www.dialight.com
 DuroSite™ RTO Series LED White Down-light Fixtures;
 a.k.a. Jelly Jar lamps
 Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments;
 - 2. City Preapproved Equal

2.7 INTERIOR/EXTERIOR INDUSTRIAL HIGH BAY LUMINARIES

- A. Features include:
 - 1. Low power consumption;
 - 2. Instant on/off response;
 - 3. Weather/corrosion resistant lamp assembly and housing;
 - 4. Polycarbonate lens for wet environments, Tempered glass lens for others;
 - 5. 120/277VAC or 347-480VAC, 60-Hertz;
 - 6. Resistant to shock and vibration;
 - 7. 5-Year Warranty;
 - 8. 80% lumen maintenance after 60,000 hours;
 - 9. NEMA 4X (IP66);
 - 10. UL1598;
- B. Acceptable Interior/Exterior Industrial High Bay Luminaire Manufacturers
 - 1. DIALIGHT CORPORATION
www.dialight.com
 DuroSite™ Series LED High Bay Fixtures with Occupancy Sensor and/or Dimming Options;
 Ideal for warehouse, garage, aisle, cold storage, bridge, tunnel and general area lighting;
 - 2. City Preapproved Equal

2.8 INTERIOR/EXTERIOR INDUSTRIAL LINEAR LUMINARIES

- A. Features include:
 - 1. Low power consumption;
 - 2. Instant on/off response;
 - 3. Weather/corrosion resistant lamp assembly and housing;
 - 4. 120/277VAC, 60-Hertz;
 - 5. Resistant to shock and vibration;
 - 6. 10-Year Warranty;
 - 7. >70% lumen maintenance over 100,000 operating hours;
 - 8. IP65;
 - 9. UL1598;
 - 10. Operating Temp: -40°F to +149°F (-40°C to +65°C)
- B. Acceptable Interior/Exterior Industrial Linear Luminaire Manufacturers
 - 1. DIALIGHT CORPORATION
www.dialight.com

DuroSite™ LTM Series LED Linear Fixtures, Cool White with Wide Optics;
Rugged and durable for demanding industrial and utility lighting applications;

2. City Preapproved Equal

2.9 INTERIOR/EXTERIOR HAZARDOUS LOCATION BULKHEAD AREA LUMINARIES

A. Features include:

1. Low power consumption;
2. Instant on/off response;
3. Mercury Free;
4. 120/277VAC, 60-Hertz;
5. Resistant to shock and vibration;
6. 5-Year Warranty;
7. 70% lumen maintenance over 100,000 operating hours;
8. UL 844;
9. Ex II 2G D Ex d e mb IIC T6 Gb; w Ex tb IIIC T85° Db;
10. ATEX Zones 1 & 21 and 2 & 22;
11. IP66 & IP67;
12. Operating Temp: -40°F to +149°F (-40°C to +65°C)

B. Acceptable Interior/Exterior Hazardous Location Bulkhead Area Luminaire Manufacturers

1. DIALIGHT CORPORATION

www.dialight.com

SafeSite® HZ Series LED Wallpack / Bulkhead Fixtures;
Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments

2. City Preapproved Equal

2.10 INTERIOR/EXTERIOR HAZARDOUS LOCATION DOWN-LIGHT AREA LUMINARIES

A. Features include:

1. Low power consumption;
2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. 120/277VAC, 60-Hertz;
5. Resistant to shock and vibration;
6. 5-Year Warranty;
7. 70% lumen maintenance over 100,000 operating hours;
8. NEMA 4X (IP66);
9. Class I, Division 2, Groups A, B, C, D;
10. Operating Temp: -40°F to +149°F (-40°C to +65°C)
11. Hazardous environments T3C rated (-40 °C - +55 °C);
12. UL844 / UL1598;

B. Acceptable Interior/Exterior Hazardous Location Down-light Area Luminaire Manufacturers

1. DIALIGHT CORPORATION
www.dialight.com
 SafeSite® Series RTO LED White Down-light Fixtures;
 a.k.a. Jelly Jar lamps
 Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway
 and other industrial environments;
2. City Preapproved Equal

2.11 INTERIOR/EXTERIOR HAZARDOUS LOCATION HIGH BAY LUMINARIES

- A. Features include:
 1. Low power consumption;
 2. Instant on/off response;
 3. Weather/corrosion resistant lamp assembly and housing;
 4. 120-277VAC, 60-Hertz;
 5. Resistant to shock and vibration;
 6. 5-Year Warranty;
 7. 70% lumen maintenance over 100,000 operating hours;
 8. NEMA 4X (IP66);
 9. Class I, Division 2, Groups A, B, C, D;
 10. Hazardous environments T3C rated (-40 °C - +55 °C);
 11. UL 844 / UL1598;
- B. Acceptable Interior/Exterior Hazardous Location High Bay Luminaire Manufacturers
 1. DIALIGHT CORPORATION
www.dialight.com
 SafeSite® Series LED High Bay Fixtures;
 Ideal for warehouse, garage, aisle, cold storage, bridge, tunnel and
 general area lighting;
 2. City Preapproved Equal

2.12 INTERIOR/EXTERIOR HAZARDOUS LOCATION LINEAR LUMINARIES

- A. Features include:
 1. Low power consumption;
 2. Instant on/off operation;
 3. 100/277VAC, 60-Hertz;
 4. Mercury Free;
 5. Resistant to shock and vibration;
 6. Temperature compensation technology for longer life;
 7. 10-Year Warranty;
 8. 70% lumen maintenance over 100,000 operating hours;
 9. NEMA 4X (IP66);
 10. Class I, Div 2;
 11. UL 1598A;
 12. Operating Temp: -40°F to +149°F (-40°C to +65°C)
- B. Acceptable Interior/Exterior Hazardous Location Linear Luminaires Manufacturers
 1. DIALIGHT CORPORATION

www.dialight.com

SafeSite™ LSD Series LED Linear Fixtures;

Designed specifically to replace fluorescent lighting fixtures in industrial and hazardous location applications;

2. City Preapproved Equal

2.13 EXTERIOR AREA/STREET LIGHTS

A. Features include:

1. Low power consumption;
2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. Universal power inputs;
5. Resistant to shock and vibration;
6. Field replaceable power supply;
7. Built-in thermal overload protection circuitry;
8. 5-Year Warranty;
9. UL1598;
10. UL 8750;

B. Acceptable Exterior Area/Street Lights Manufacturers

1. DIALIGHT CORPORATION

www.dialight.com

StreetSense™ Series LED Street Light Fixtures with Photo Controller Option;

Designed for easy installation & maintenance;

2. City Preapproved Equal

C. Exterior Concrete Poles:

1. Type I Pre-stressed Octagon concrete pole;
2. 20-foot length, 4-inch tip minimum, 7.25-inch butt minimum; or per Contract Drawings;
3. All corners chamfered, smooth surface, no cracks;
4. 7,000 PSI concrete;
5. Handhold shall measure 3-inch Deep x 6-inch Wide x 8-inch Height minimum; or per Contract Drawings;
6. Two cable entrances to internal raceway with couplings shall be cast in all poles 90 degrees to the handhold; or per Contract Drawings;
7. A PVC conduit for a ground wire shall be included parallel to raceway;
8. Include concrete collar as required by the Luminaire Manufacturer and Wind Load Calculations;
9. Lighting assembly to be certified per Florida Building Code;
10. Contractor shall submit signed and sealed Wind Load Calculations from a Structural Engineer licensed in the State of Florida;
11. City to select Color & Finish;
12. Pole shall be sealed with anti-graffiti coating;

D. Acceptable Exterior Concrete Pole Manufacturers

1. LONESTAR PRESTRESS MFG. INC.

www.lonestarprestress.com

Type I Pole;

Typical part nos. are comprised based on total length, type of pole based on strength & engineering, fixture mounting, brackets and color & finish;

2. PRE-CAST SPECIALTIES, INC.

www.precastspecialties.com

Type I Pole;

Typical part nos. are comprised based on total length, type of pole based on strength & engineering, fixture mounting, brackets and color & finish;

3. City Preapproved Equal

E. Exterior Aluminum Poles:

1. Seamless round extruded aluminum tube, welded aluminum top and bottom;
2. 12-foot length, 4-inch round minimum; or per Contract Drawings;
3. Smooth surface, no cracks;
4. All anchoring hardware shall be stainless steel;
5. Handhold shall be 18" up from base, with a gasketed cover and ground lug; or per Contract Drawings;
6. Two cable entrances to internal raceway with couplings shall be in all poles 90 degrees to the handhold; or per Contract Drawings;
7. A PVC conduit for a ground wire shall be included parallel to raceway;
8. Include appropriate collar as required by the Luminaire Manufacturer and Wind Load Calculations;
9. Lighting assembly to be certified per Florida Building Code;
10. Contractor shall submit signed and sealed Wind Load Calculations from a Structural Engineer licensed in the State of Florida;
11. City to select Color & Finish;
12. Pole shall be sealed with anti-graffiti coating;

F. Acceptable Exterior Aluminum Pole Manufacturers

1. HAPCO
www.hapco.com
Round Straight Aluminum,
RSA Pole Series;
2. KIM LIGHTING, INC.
www.kimlighting.com
Round Aluminum (Non-Tapered),
PRA Pole Series;
3. City Preapproved Equal

2.14 EMERGENCY LIGHTING COMMERCIAL SINGLE/TWO FACE
THERMOPLASTIC EXIT 120/277VAC LIGHT WITH NICAD BATTERY;

A. Features include:

1. Universal mounting (wall, ceiling or end—canopy provided) installation;
2. 5-Year Warranty;
3. Life Safety NFPA 101;
4. UL 924 Listed;
5. UL listed for Damp Location use;

- B. Acceptable Emergency Lighting Commercial Single/Two Face Thermoplastic Exit 120/277VAC Light with NiCad Battery Manufacturers
 - 1. PHILIPS CHLORIDE
www.chloridesys.com
 Commercial Exit Signs, CXX Series - COMPAC Thermoplastic LED Exit with Xtest™ Self-Diagnostics,
 Part No. CXXL-3-R-W-DR, where
 CXXL = LED Emergency with Xtest™ Diagnostics, NiCad Battery;
 3 = Universal (includes extra stencil face plate);
 R = Red Panel Color;
 W = White Housing Color;
 DR = Damp Location Rating;
 - 2. City Preapproved Equal
- 2.15 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE CLASS I & II, DIVISION 2 EXIT 120/277VAC LIGHT WITH NICAD BATTERY;
- A. Features include:
 - 1. 5-Year Warranty (excluding lamps);
 - 2. Life Safety NFPA 101;
 - 3. UL 924 and UL 844 Listed;
 - 4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
 - 5. Provides a minimum of 90-minutes of emergency power;
 - B. Acceptable Emergency Lighting Industrial Single Face Class I & II, Division 2 Exit 120/277VAC Light with NiCad Battery Manufacturers
 - 1. PHILIPS CHLORIDE
www.chloridesys.com
 Hazardous Emergency HZ Series, Class I & II, Division 2 Exit Sign
 Part No. HZNRIC, where:
 HZ = Hazardous Location LED Exit Series;
 N = Nickel Cadmium Battery;
 R = Red LED Letter Color;
 IC = Intelli-Charge Diagnostics Model;
 T = Self-Testing Diagnostics Option;
 - 2. City Preapproved Equal
- 2.16 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE NEMA 4X EXIT LIGHT COMBO 120/277VAC WITH NICAD BATTERY;
- A. Features include:
 - 1. 5-Year Warranty;
 - 2. Life Safety NFPA 101;
 - 3. UL 924 Listed;
 - 4. UL Listed for wet locations;
 - B. Acceptable Emergency Lighting Industrial Single Face NEMA 4X Exit Light 120/277VAC with NiCad Battery Manufacturers
 - 1. PHILIPS CHLORIDE
www.chloridesys.com

Industrial Exit Signs, NEMA Series Harsh Environment Combo,
Part No. N2HLRW, where
N2H = Two Head Combination Series, Lead Calcium Battery;
L = LED Lamp Type;
R = Red LED Stencil Face/Letter Color;
W = Wet Location Listing;
CH-40500

2. City Preapproved Equal

2.17 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE CLASS I & II, DIVISION 2 EXIT LIGHT COMBO 120/277VAC WITH NICAD BATTERY:

- A. Features include:
 1. 5-Year Warranty (excluding lamps);
 2. Life Safety NFPA 101;
 3. UL 924 and UL 844 Listed;
 4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
 5. Provides a minimum of 90-minutes of emergency power;
- B. Acceptable Emergency Lighting Industrial Single Face Class I & II, Division 2 Exit Light Combo 120/277VAC with NiCad Battery Manufacturers
 1. PHILIPS CHLORIDE
www.chloridesys.com
Hazardous Emergency HZ Series, Class I & II, Division 2 Combo,
Part No. HZ636R2ZYICT, where:
HZ = Hazardous Location LED Exit Series;
6 = 6VDC System Voltage;
36 = 36-watt Lead Calcium Battery;
R = Red LED Letter Color;
2 = Quantity of Lamp Heads;
ZY = 6-watt Halogen Lamp Heads;
IC = Intelli-Charge Diagnostics Model;
T = Self-Testing Diagnostics Option;
 2. City Preapproved Equal

2.18 COMMERCIAL COMPACT NON-METALLIC, CORROSION RESISTANT EMERGENCY LIGHTING 120/277VAC UNIT WITH NICAD BATTERY

- A. Features include:
 1. Low profile meets ADA specifications on lighting fixtures;
 2. 5-Year Warranty;
 3. NFPA 70;
 4. Life Safety NFPA 101;
 5. UL 924 Listed;
- B. Acceptable Commercial Compact Non-Metallic, Corrosion Resistant Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers
 1. PHILIPS CHLORIDE
www.chloridesys.com

Commercial Emergency CAX6 Series COMPAC® Semi-Recessed Head Thermoplastic Emergency Unit with Xtest™, Part No. CAX6NH-DR, where CAX6NH = 6VDC, NiCad Battery, white housing, 8 watt halogen MR16 lamps;

DR = Damp Rating;

2. City Preapproved Equal

2.19 INDUSTRIAL NON-METALLIC, CORROSION RESISTANT NEMA 4X EMERGENCY LIGHTING 120/277VAC UNIT WITH NICAD BATTERY

A. Features include:

1. 5-Year Warranty (excluding lamps);
2. Life Safety NFPA 101;
3. UL 924 Listed;
4. UL Listed for wet locations;

B. Acceptable Industrial Non-Metallic, Corrosion Resistant NEMA 4X Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers

1. PHILIPS CHLORIDE

www.chloridesys.com

Industrial Emergency 4X Series,

Part No. 4X6N50J962W, where

4X = 4X Series;

6 = 6VDC;

N = Nickel Cadmium Battery;

50 = 50-watt DC Wattage;

J96 = 6V, 9-watt;

2 = Quantity of Lamp Heads;

W = UL Wet Location Listing;

2. City Preapproved Equal

2.20 INDUSTRIAL NON-METALLIC, CLASS I & II, DIVISION 2 EMERGENCY LIGHTING 120/277VAC UNIT WITH BATTERY:

A. Features include:

1. 5-Year Warranty (excluding lamps);
2. Life Safety NFPA 101;
3. UL 924 and UL 844 Listed;
4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
5. Wall-mount;
6. Provides a minimum of 90-minutes of emergency power;

B. Acceptable Industrial Non-Metallic, Class I & II, Division 2 Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers

1. PHILIPS CHLORIDE

www.chloridesys.com

Hazardous Emergency Steel-Lite Series, Class I & II, Division 2 Emergency Unit,

Part No. STC100ZK2ICT, where:

STC100 = 100-watt 12V, Lead Calcium Series;
 ZK = 8-watt 12VDC Halogen Lamp Heads;
 2 = Quantity of Lamp Heads;
 IC = Intelli-Charge Diagnostics Model;
 T = Self-Testing Diagnostics Option;

2. City Preapproved Equal

2.21 INTERIOR COMMERCIAL LOCATION T8 FLUORESCENT FIXTURE UPGRADE TO LED

- A. Features include:
 1. 100/277VAC, 60-Hertz, +/-10%, Internal Driver;
 2. Lamps fit into existing linear fluorescent fixtures (G13);
 3. UL 1598C compliance (ensures the fixture maintains original UL compliance);
 4. Glass free;
 5. 5-Year Limited Warranty;
- B. Acceptable Interior Commercial Location T8 Fluorescent Fixture Upgrade to LED Manufacturers
 1. PHILLIPS LIGHTING COMPANY
www.philips.com
 COREPRO LED Lamps
 2. OSRAM SYLVANIA
www.sylvania.com
 Commercial Grade LED T8 Lamps

2.22 LAMPS

- A. Non-LED Lamps are for existing installations and control panel enclosures only;
 1. Linear Fluorescent (FL);
 2. Compact Fluorescent (CFL);
 3. High-Intensity Discharge (HID);
 4. High Pressure Sodium (HPS);
 5. Light-Emitting Diode (LED);
- B. Acceptable Lamp Manufacturers
 1. GENERAL ELECTRIC
www.gelighting.com
 2. NORTH AMERICAN PHILLIPS
www.usa.philips.com
 3. SYLVANIA
www.sylvania.com

2.23 BALLASTS

- A. Ballasts are for existing installations only;
 1. High-efficiency;
 2. NEMA Premium® Electronic fluorescent;
 3. Energy Independence and Security Act (EISA) compliant;
 4. No magnetic ballasts accepted;

5. Minimum 3-Year Warranty;
6. UL Listed;
- B. Acceptable Ballast Manufacturers
 1. PANASONIC UNIVERSAL™ LIGHTING TECHNOLOGIES
www.unvlt.com
 Universal® Lighting Products;
 2. PHILIPS LIGHTING ELECTRONICS
www.advance.philips.com
 Philips Advance® Lighting Products

2.24 BALLASTS

- A. Ballasts are for existing installations only;
 1. High-efficiency;
 2. NEMA Premium® Electronic fluorescent;
 3. Energy Independence and Security Act (EISA) compliant;
 4. No magnetic ballasts accepted;
 5. Minimum 3-Year Warranty;
 6. UL Listed;
- B. Acceptable Emergency Ballast Manufacturers
 1. PANASONIC UNIVERSAL™ LIGHTING TECHNOLOGIES
www.unvlt.com
 Universal® Emergency Lighting Products;
 2. PHILIPS EMERGENCY LIGHTING
www.bodine.com
 Philips Bodine® Emergency Lighting Products;
 Application specific;

2.25 PHOTOCELLS

- A. Application dependent:
 1. ½-inch Knock-out for Exterior Luminaire Control;
 2. Twist-lock for Street, Highway, Parking Lot and other luminaries equipped with locking type receptacles;
 3. Single-gang Junction Box Mounting for Interior/Exterior Control;
 4. UL Listed;
 5. 5-Year Warranty;
- B. Acceptable Photocell Manufacturers
 1. INVENSYS® CONTROLS PARAGON® ELECTRICAL PRODUCTS
www.paragontimecontrols.com
 PARAGON®;
 2. NSI INDUSTRIES LLC
www.tork.com
 TORK®;

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Each fixture shall be a completely finished unit with all components, mounting and/or hanging devices necessary, for the proper installation of the particular fixture in its designated location and shall be completely wired ready for connection to the branch circuit wires at the outlet;
- B. When fixtures are noted to be installed "flush", they shall be complete with the proper accessories for installing in the particular ceiling involved; All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceiling for their support;
- C. Flexible fixture hangers shall be used for all pendant mounted fixtures;
- D. Receptacles shall be mounted 36-inches above the floor unless otherwise noted on the Contract Drawings;
- E. Concrete poles shall be installed per Manufacturer's instructions and as noted on the Contract Drawings;

3.2 ADJUSTING AND CLEANING

- A. The luminaries shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.3 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

- A. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- B. Verify that all luminaries are installed and connected according to the Contract Documents.
- C. Verify that wiring installation complies with requirements in Division 16 Sections.
- D. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

- A. At a minimum, Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment. All standard warranties that provide additional protection shall be transferred to the City;

3.6 WARRANTY (PROJECT)

- A. At a minimum, Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion. All standard warranties that provide additional protection shall be transferred to the City;

End of Section

Section 16670

LIGHTNING PROTECTION SYSTEM (LPS)

PART 1 - GENERAL

1.1 SCOPE

- A. Provide complete lightning protection system (design, materials, labor, installation, testing, etc.) for all of the following facilities:
 - 1. Pumps, motors, building, light poles, antenna, fence, etc.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
 - a. Section 16450 - Grounding System for grounding and bonding specifics;
 - b. City of Orlando, Standard details
- C. The work includes, but is not limited to, furnishing and installing air terminals, grounding conductors, connectors, fasteners, ground rods and other materials necessary for a complete protective system.
- D. Lightning protection system design shall comply with all applicable provisions of Lightning Protection Institute (LPI) 175 and 176, Underwriters Laboratories (UL) 96 and 96A and National Fire Protection Association® (NFPA®) 780.

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. Lightning Protection Institute (LPI) 175 - Installation Standard;
 - 2. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 3. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 5. NFPA® 70E® - Electrical Safety in the Workplace;
 - 6. NFPA® 780 – Standard for the installation of Lightning Protection Systems (latest edition);
 - 7. Underwriters Laboratories (UL) 96 - Safety Lightning Protection Components;

8. UL 96A - Safety Installation Requirements for Lightning Protection Systems;
9. UL 467 - Grounding and Bonding Equipment;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. Design Drawings and plans shall be developed and provided to the Owner that describe the Lightning Protection System layout at each facility with each component and method of connection used;
 1. Descriptive bulletins;
 2. Product data sheets;
 3. Master drawing index;
 4. Dimensioned front & plan view of the assembly;
 5. Schematic diagram;
 6. Cable terminal sizes;
 7. Component list;
 8. Conduit space entry/exit locations;
 9. Ratings;
 10. Wiring diagrams;
 11. Installation information;
- E. Detailed plans shall include:
 1. Down conductor;
 2. Connecting conductor;
 3. Bond strap;
 4. Air terminals;
 5. Fittings;
 6. Connectors;
 7. Ground rods;
- F. Quality Control Submittals: Field test report;
- G. Contract Closeout Submittals: Submit to Owner:
 1. Ground Witness Certification - Form LPI-175A;
 2. Post-Installation System Certification;
 3. UL 96 Master Label "C" Certification;

1.4 QUALITY ASSURANCE

- A. Designer: Lightning protection system design shall be prepared by an LPI-

- certified designer or recognized Lightning Protection Manufacturer.
- B. Manufacturer: All system components shall be the product of a single Manufacturer regularly engaged in the manufacturing of lightning protection components in accordance with LPI 176 and UL 96.
- C. Installer: Lightning Protection System shall be installed under the direct supervision of an LPI 175 Certified Master Installer.
- D. Inspector: Final installation and grounding connection inspection of the System shall be performed by the Owner representative or agent in accordance with LPI 177.
- E. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing mark.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Only copper components shall be used except on aluminum or galvanized steel surfaces;
- B. Whenever aluminum components are used:
 - 1. Contractor shall provide aluminum components equivalent to the specified copper component's current carrying capability and mechanical strength, and
 - 2. Transition back to copper before entering the PVC down chase;
 - 3. No aluminum shall be allowed at or below grade;
- C. The completed system(s) shall bear the UL 96 Master Label "C";
- D. All material shall comply in weight, size, and composition for the class of structure to be protected as established by UL 96 and 96A.

2.2 AIR TERMINALS

- A. Material: Solid copper rods, minimum 3/8-inch, with tapered points;
- B. Length: Sufficient to extend minimum 10-inches above object being protected;
- C. UL 96 Label B applied to each terminal;

2.3 CONDUCTORS

- A. Copper Cable: Bare medium stranded, having 97.5 percent minimum conductivity;
- B. Main Down Conductor: Per UL and NFPA criteria and based on building height;
- C. Connecting Conductor: Secondary size per UL and NFPA criteria;
- D. Bonding Conductor: Flexible strap, minimum 3/4-inch wide by 1/8-inch thick;
- E. All main down and connecting conductors shall bear the UL 96 Label A, applied every 10-feet;

2.4 CABLE FASTENER AND ACCESSORIES

- A. Cable fasteners and accessories shall be capable of withstanding a minimum pull of 100-pounds;

2.5 FITTINGS

- A. Heavy-duty Class II Bolt pressure type;
- B. Bolts, Screws and Related Hardware: Type 316 Stainless steel;

2.6 GROUND RODS

- A. Material: Copper clad steel 3/4-inch x 20-feet long UL 467 Listed.
- B. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.7 GROUNDING CONNECTIONS

- A. Welds: Exothermic process;
- B. Fasteners: Bolted clamp type, corrosion-resistant copper alloy;
- C. Hardware: Type 316 Stainless Steel;
- D. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.8 CABLE CONNECTIONS AND SPLICES

- A. Welds: Exothermic process (underground).
- B. Fasteners: Bolted clamp type, corrosion-resistant copper alloy (above grade).
- C. Through-Roof Connectors: Straight or right angle with lead flashing washer and other appurtenances to match existing roofing system.
- D. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.9 CONDUIT

- A. Schedule 40 PVC, as specified in Section 16110 - Raceways, Boxes and Fittings;

2.10 ACCEPTABLE MANUFACTURERS

- A. The listing of specific Manufacturers below does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed below are not relieved from meeting the specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Owner ten (10) days prior to bid date.
- B. All Lightning Protection Institute (LPI) Component Manufacturers (www.lightning.org);
 - 1. EAST COAST LIGHTNING EQUIPMENT INC.
www.ecle.biz
 Winsted, CT
 (800) 833-3253
 (860) 379-9072
 - 2. ERICO® PRODUCTS INC.
www.erico.com
 Solon, OH
 (440) 248-0100
 - 3. HARGER LIGHTNING & GROUNDING
www.harger.com
 Grayslake, IL
 (800) 842-7437
 (847) 548-8700
 - 4. HEARY BROS. LIGHTNING PROTECTION
www.hearybros.com
 Springville, NY
 (800) 421-6141
 (716) 941-6141
 - 5. INDEPENDENT PROTECTION CO., INC.
www.ipclp.com
 Goshen, IN
 (800) 860-8388
 (574) 533-4116
 - 6. LIGHTNING MASTERS CORP.
www.lightningmaster.com
 Clearwater, FL
 (800) 749-6800
 (727) 447-6800
 - 7. NATIONAL LIGHTNING PROTECTION CORP.
www.theprotectionsource.com
 Aurora, CO
 (800) 628-2816
 (303) 295-1695

8. PREFERRED LIGHTNING PROTECTION
www.preferredlp.com
Maryville, MO
(866) 299-7406
(660) 562-2771
9. ROBBINS LIGHTNING PROTECTION INC.
www.robbsnlightning.com
Maryville, MO
(800) 426-3792
10. THOMPSON LIGHTNING PROTECTION, INC.
www.tlpinc.com
St. Paul, MN
(800) 777-1230
(651) 455-7661

2.11 LPS CONTRACTORS

- A. Contractor shall be a Lightning Protection Institute (LPI) 175 Certified Master Installer;
- B. All work shall require a UL 96 Master Label "C" upon completion and prior to acceptance.
 1. CENTRAL LIGHTNING PROTECTION INC.
www.centrallightningprotection.com
Orlando, FL
(407) 380-6995
 2. MCLEAN LIGHTNING PROTECTION
www.mcleanlp.com
Orlando, FL
(407) 277-9400
 3. TRIANGLE LIGHTNING PROTECTION, INC.
no website
Eustis, FL
(352) 483-7020
 4. Owner Approved LPS Contractor

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Workmanship shall comply with all applicable provisions of LPI 175, UL 96 and 96A and NFPA® 780;
- B. Installation of bare copper materials on aluminum surfaces shall not be permitted;
- C. Provide waterproof seal on all roof penetrations;
- D. Install system in inconspicuous manner so that components blend with building aesthetics;

3.2 EXAMINATION

- A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations;

3.3 AIR TERMINALS

- A. Supports: Brackets or braces;
 - A. Parapet Bracket Attachment: Lag or expansion bolts;
 - B. Secure base to roof surface with adhesive or pitch compatible with roofing bond;
 - C. Provide terminal flashing at roof penetrations;
 - D. Perimeter Terminals:
 - 1. Maximum Spacing: 20-feet;
 - 2. Maximum Distance from Outside Edge of Building: 2-feet;
 - E. Roof Ridge Terminals: Maximum spacing 20-feet;
 - F. Mid-Roof Terminals: Maximum spacing 50-feet;

3.4 CONDUCTORS

- A. Conceal whenever practical;
- B. Provide 1-inch PVC conduit in building walls or columns for main down leads and roof risers;
- C. Support: Maximum spacing for exposed conductors;
 - 1. Vertical and horizontal: 3-feet;
- D. Maintain horizontal and vertical conductor courses free from dips or pockets;
- E. Bends: Maximum 90 degrees, with minimum 8-inch radius;
- F. Install air terminal conductors on the structural roof surface before roofing composition is applied;
- G. Provide and install Bare Tinned Copper conductor for all underground wire;

3.5 BONDING

- A. Bond to Main Conductor System:
 - 1. All roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails and other sizeable metal objects;
 - 2. 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;
 - 3. Provide air terminals as required;
- B. Bond steel columns or major framing members to grounding system per NEC®;
- C. Bond each main down conductor to grounding system;

3.6 GROUNDING SYSTEM

- A. Grounding Conductor:
 - 1. Completely encircle building structure;
 - 2. Bury minimum 30-inch 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 bolted 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;

3.7 ADJUSTING AND CLEANING

- A. Upon completion of the installation, the Contractor shall inspect and adjust accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Remove any and all trash from surrounding areas and ground test well spaces.

3.8 TESTING

- A. Isolate lightning protection system from other ground conditions while performing tests.
- B. Resistance: Test ground resistance of grounding system by the fall-of-potential method;
 - 1. Test Resistance to Ground: Maximum 5 ohms;
 - 2. Install additional ground rods as required to obtain maximum allowable resistance;
- C. Test Report:
 - 1. Description of equipment tested;
 - 2. Description of test;
 - 3. Test results;
 - 4. Conclusions and recommendations;
 - 5. Appendix, including appropriate test forms;
 - 6. Identification of test equipment used;
 - 7. Signature of responsible test organization authority;

3.9 STARTUP SERVICES

- A. Verify that all devices are installed and connected according to the Contract Documents.
- B. Verify that installation complies with requirements in Division 16 Sections.
- C. Ensure UL 96 Master Label "C" Certification label is affixed to the building(s).

3.10 WARRANTY

- A. Equipment Manufacturer warrants that all goods supplied are free of non-

conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

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PROTECTORS AND SURGE PROTECTION DEVICES (SPDs)

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes the materials and installation requirements for Protectors and Surge Protective Devices (SPDs), for the protection of all electrical, measurement, control, instrumentation and communication circuits from the effects of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. For Protectors – Underwriters Laboratories (UL) divides Protectors into five separate categories:
 - a. Primary Protectors for Communication Circuits (QVGV);
 - b. Primary Protectors for Coaxial Communications Circuits (QVKC);
 - c. Protectors for Antenna Lead-in Conductors (QVLA);
 - d. Secondary Protectors for Communication Circuits (QVRG);
 - e. Isolated Loop Circuit Protectors for Communication Circuits (QVGQ)

The primary protectors are intended for installation as defined in National Electrical Code (NEC®) Article 800. Primary coaxial protectors are intended for use on coaxial communications circuits and network-powered broadband communications systems as defined in NEC® Article 830. Protectors for antenna lead-in conductors are used to limit surges on the antenna lead-in cable that connects the antenna to the receiver/transmitter electronics. The purpose of the isolated loop circuit protector is to suppress abnormal voltages caused by hazards such as lightning and other EMI transients. An isolated loop circuit protector (ILCP) is intended for use on data or communication lines that are not exposed to accidental contact with electric light or power conductors operating at over 300V to ground. An ILCP is

- intended for use on Class 2 or Class 3 Remote Control, Signaling and Power Limited Circuits or Fire Protection Signaling Circuits as defined in NEC® Articles 725 and 760 used as suppression devices for abnormal voltage conditions that may exist on the circuit due to electrical transients from an electromagnetic disturbance.
- f. UL 497 - Protectors for Paired-Conductor Communications Circuits
 - g. UL 497A - Secondary Protectors for Communications Circuits
 - h. UL 497B - Protectors for Data Communications and Fire-Alarm Circuits
 - i. UL 497C - Protectors for Coaxial Communications Circuits
 - j. American National Standards Institute (ANSI) / Institute Of Electrical And Electronic Engineers (IEEE) C62.41 - Location Category A and B
 - k. International Electrotechnical Commission (IEC) 61643-21 - Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signaling networks – Performance requirements and testing methods;
2. For SPDs - designed for repeated limiting of transient voltage surges as specified in the ANSI/UL 1449 Standard on 60-Hertz power circuits not exceeding 1000V and designated as follows:
- a. Type 1 - permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device;
 - b. Type 2 - permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch panel;
 - c. Type 3 - point of utilization SPDs, installed at a minimum of 10 meters (30 feet) from the electrical service entrance, for example cord connected, direct plug-in, receptacle type and SPDs installation the utilization equipment being protected;
 - d. Type 4 - component SPD, including discrete components as well as component assemblies;
- The above Type SPDs have been certified by UL that the average of the transient voltage surges is limited to the Voltage Protection Rating (VPR) marked on the product. The VPR is a rating selected from a list of preferred values as given in Table 63.1 of ANSI/UL 1449 and assigned to each mode of protection. The value of the VPR is determined as the nearest highest value taken from Table 63.1 to the measured limiting voltage determined during the transient-voltage surge suppression test using the combination wave generator at a setting of 6 kV/3 kA. Mode(s) Refers to the pair of electrical connections where the

VPR applies. The term "ALL" indicates that the VPR applies to all combinations of pairs of electrical connections. UL SPD Type Testing of Type 1 and 2 SPDs are subjected to a Nominal Discharge Current test where an 8 x 20 microsecond surge current (magnitude specified by the Manufacturer) is impressed through the SPD. Type 3 SPDs are subjected to an Operating Duty Cycle test with a combination wave at 6 kV/3 kA.

- e. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) C62.41.1-2002 - Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits;
- f. ANSI/IEEE C62.41.2-2002- Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits;
- g. ANSI/IEEE C62.45-2002 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- h. ANSI/ Underwriters Laboratories (UL) 1449 - Surge Protective Devices, 3rd Edition;
- i. National Electrical Manufacturers Association (NEMA) LS-1 - Low-Voltage Surge-Protection (LVSP) Devices;
- j. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
- k. NEC® Article 285 – Surge-Protective Devices (SPDs), 1kV or Less;
- l. NFPA® 70E® - Electrical Safety in the Workplace;
- m. UL 1283 - Electromagnetic Interference Filters;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. Shop Drawings shall be submitted and consist of a complete list of materials, including Manufacturer's descriptive and technical literature, catalog cuts, drawings and installation instruction;
 - 1. For Protectors
 - a. Submit electrical/electronic product data on each protector type, including (any & all applicable)

- i. Complete part numbers and specific application reference;
 - ii. Maximum input power;
 - iii. Nominal impedance;
 - iv. Nominal & Maximum line voltage;
 - v. Maximum line & Impulse current
 - vi. Protection level;
 - vii. Nominal & Maximum discharge current;
 - viii. Clamping voltage;
 - ix. Peak pulse current;
 - x. Response time;
 - xi. Maximum shunt capacitance;
 - xii. Maximum data rate;
 - b. Submit physical product data on each protector type, including –
 - i. Connection method;
 - ii. Connector (in and out);
 - iii. Grounding;
 - iv. Housing material;
 - v. Dimensional drawing showing mounting arrangements;
 - vi. Operating temperature;
 - vii. Humidity;
 - c. Submit Manufacturer's certified test data for each protector type confirming a "shorted" failure mode;
 - d. Copy of extended warranty;
2. For SPDs
- a. Submit product data on each suppressor type indicating component values including
 - i. Complete electrical ratings including the operating voltage rating (volts), ac power frequency (Hertz), number of phases, and load current rating (amperes);
 - ii. VPR in volts for all modes;
 - iii. Nominal Discharge Current (In) Rating in amps;
 - iv. Maximum Continuous Operating Voltage Rating (MCOV) in volts;
 - v. Short-circuit Current Rating (SCCR) in amps;
 - vi. I-nominal rating (I-n);
 - vii. Complete part numbers and conductor sizes;
 - viii. Dimensional drawing for each SPD, showing mounting arrangements;
 - b. Submit UL approved installation instructions in compliance with listing requirements;
 - c. Submit Manufacturer's certified test data for each suppressor type confirming a "shorted" failure mode;
 - d. Copy of extended warranty;

1.4 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.

- B. Manufacturer shall be ISO certified.
- C. UL Listing Requirements
 - 1. For Protectors
 - a. Each Protector shall be listed per UL 497 certification to ensure comparable test evaluations and accessibility of UL's website to verify specification compliance;
 - b. Each Protector shall bear the UL Mark and shall be listed to most recent editions of UL 497;
 - c. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
 - d. Protector shall be posted at www.UL.com under Category Code: QVGV, QVKC, QVLA, QVRG or QVGQ. Products or parameters without posting at UL.com shall not be approved. To access UL Category Code QVGV, QVKC, QVLA, QVRG or QVGQ, click on Certifications in the bottom menu bar of UL's home page. Type QVGV, QVKC, QVLA, QVRG or QVGQ into the Category Code search box and click Search.
 - 2. For SPDs
 - a. Each SPD shall be listed or recognized per ANSI/UL 1449 Third Edition certification to ensure comparable test evaluations and accessibility of UL's website to verify specification compliance;
 - b. Each SPD shall bear the UL Mark and shall be listed to most recent editions of ANSI/UL 1449 and may have UL 1283 complimentary listing;
 - c. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification.
 - d. SPD and performance parameters shall be posted at www.UL.com under Category Code: VZCA or VZCA2. Products or parameters without posting at UL.com shall not be approved. To access UL Category Code VZCA or VZCA2, click on Certifications in the bottom menu bar of UL's home page. Type VZCA or VZCA2 into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 CITY STANDARDIZATION

- A. Approximately 90% of the City's installed Protectors & SPDs throughout the City's facilities are DEHN. The City has invested thousands of man-hours creating standards (control circuits and wiring diagrams) to facilitate the protection of field devices. The City has invested hundreds of man-hours training their personnel and thousands of dollars purchasing & stocking spare units and parts to maintain, trouble-shoot, repair and replace these Protectors & SPDs using "fully-tested" procedures and standards. The integration of another Manufacturer's product would vastly increase the integration efforts, maintenance costs and overall life-cycle costs for the City. Therefore, Protector & SPD components shall be as specified and assembled such that the intended function is achieved.

2.2 MEASUREMENT, CONTROL, INSTRUMENTATION AND FIELD BUS COMMUNICATION APPLICATIONS WITHIN AL PANEL

- A. Protector shall be modular DIN rail insertion into low energy measurement, control, or communication circuits (typically twisted pair with or without a ground shield), so as to protect the components, controllers, programmable logic controllers (PLCs), remote terminal units (RTUs), and measuring instruments at either end of the circuit, against high energy transients;
- B. Protector shall use a pluggable module which contains the protector circuitry, permitting the removal of this module to be accomplished without the use of tools or without interruption of the circuit due to a pair of bypass contacts;
- C. Protector and base shall have been tested and passed sinusoidal & random vibration tests up to 500-Hertz and shock tests up to 30g in all three axes;
- D. Protector shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally;
- E. Protector shall meet or exceed the following criteria:
- F. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;
- G. Clamping (let through) voltage shall not be in excess of protected circuit volts;
- H. Protector shall be replaceable without removing individual conductors or without tools (pluggable protector elements) while maintaining circuit continuity (removing the protector module shall not render the control circuit inoperable);
- I. Acceptable Measurement, Control, Instrumentation and Field Bus Communication Applications Within al Panel Manufacturers
 - 1. DEHN, INC.
www.dehn-usa.com
 BLITZDUCTOR® SP;
 Part No. 920 300 BXT BAS;
 Part No. 926 320 BSP M4 BE 5;
 Part No. 926 322 BSP M4 BE 12;

- Part No. 926 324 BSP M4 BE 24;
- Part No. 926 325 BSP M4 BE 48;
- Part No. 926 326 BSP M4 BE 60;
- Part No. 926 327 BSP M4 BE 180;
- Part No. 926 270 BSP M2 BE HF 5;
- BXT & BSP Module Base;
- 5V;
- 12V;
- 24V & 4-20mA;
- 48V;
- 60V;
- 180V;
- Profibus DP;
- 2. NO EQUAL

2.3 IEEE 802.3 ETHERNET COMMUNICATION APPLICATIONS IN CONTROL PANELS (TYPE 2)

- A. Suppressor shall be a RJ-45 Female Connector on each side for Cat 6 applications up to 48V for use in Ethernet, Gigabit Ethernet, ATM, ISDN, Voice over IP (VoIP) and Power over Ethernet (PoE) applications;
- B. Suppressor shall provide surge protection of all pairs with heavy duty gas discharge tubes and a low capacitance diode matrix per pair (fully shielded universal surge arrester);
- C. Suppressor shall be Din rail mount or wall mounted with supporting foot;
- D. Suppressor shall meet or exceed the following criteria:
 - 1. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;
 - 2. Clamping (Let Through) voltage shall not be in excess of 48VDC;
- E. Acceptable IEEE 802.3 Ethernet Communication Applications In Control Panels (Type 2) Manufacturers.
 - 1. DEHN, INC.
www.dehn-usa.com
 DEHNpatch®
 Part No. 929 121 DPA M CLE RJ45B 48;
 - 2. NO EQUAL

2.4 COAXIAL COMMUNICATION APPLICATIONS IN CONTROL PANELS

- A. Suppressor shall be a BNC Connector on each side for coaxial applications up to 8VDC for use in video, radio, Wi-Fi, Wi-Max and cable applications;
- B. Suppressor shall provide surge protection of all with heavy duty gas discharge tubes and a low capacitance diode matrix (fully shielded universal surge arrester);
- C. Suppressor shall be Din rail mount or wall mounted with supporting foot;
- D. Suppressor shall meet or exceed the following criteria:
 - 1. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;
 - 2. Clamping (Let Through) voltage shall not be in excess of 8VDC;

E. Acceptable Coaxial Communication Applications In Control Panels
Manufacturers

1. DEHN, INC.
www.dehn-usa.com
DEHNgate®
Part No. 929 0XX DGA;
XX = See catalog for specifics;
2. POLYPHASER® CORPORATION
www.protectiongroup.com
Broadband dc Blocked Protector,
Part No. IS-B50HN-C2-ME Antenna surge suppression;
Lift Stations MOTOROLA MOSCAD® Panels;
3. POLYPHASER® CORPORATION
www.protectiongroup.com
Broadband dc Blocked Protector,
Part No. IS-B50NX-C1-ME Antenna surge suppression;
Lift Stations MOTOROLA MOSCAD® ACE3600 Panels;
4. NO EQUAL

2.5 MEASUREMENT, CONTROL AND INSTRUMENTATION APPLICATIONS IN EXPOSED OUTDOOR ENVIRONMENTS

- A. Suppressor shall be built within a corrosion-resistant stainless steel threaded pipe mounted in exposed outdoor environments and is attached by screwing the threaded end into the housing of the instrument it is protecting, primary application is for 24VDC, 4-20 or 0-20 mA DC loop circuits;
- B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally;
- C. Suppressor shall meet or exceed the following criteria:
- D. Provide units with a maximum single impulse current rating of 10,000-amperes (8 x 20 microseconds – current waveform) per mode;
- E. Clamping (Let Through) voltage shall not be in excess of 36VDC;
- F. Acceptable Measurement, Control and Instrumentation Applications In Exposed Outdoor Environments Manufacturers
 1. DEHN, INC.
www.dehn-usa.com
DEHNpipe®
Part No. 929 921 DPI ME 24 N A2G;
 2. NO EQUAL

2.6 POWER APPLICATIONS WITHIN CONTROL PANELS, SINGLE POLE AND TWO POLE (TYPE 2)

- A. Suppressor shall be DIN rail mountable;
- B. Suppressor shall be MOV design with a thermal disconnect;
- C. Suppressor shall have a visible status indicator;
- D. Suppressor protection elements (MOV) shall be replaceable without the use of tools (i.e. pluggable);

- E. Suppressor shall have unpowered Form C contacts for remote status indication;
- F. Suppressor shall meet or exceed the following criteria:
 - 1. Maximum single impulse current rating: 40,000 amperes (8 x 20 microsecond -- waveform);
 - 2. Suppressed Voltage rating on no greater than 400VAC peak;
- G. Acceptable Power Applications Within Control Panels, Single Pole (Type 2) Manufacturers
 - 1. DEHN, INC.
www.dehn-usa.com
 DEHNguard®
 Part No. 952 0XX DG S XX FM;
 Use in Single Line Circuit Applications Only
 XX =
 91 for 75V;
 92 for 150V;
 98 for 48V;
 - 2. DEHN, INC.
www.dehn-usa.com
 DEHNguard®
 DG M TN 150 FM
 Part No. 952 206
 Use in 120vac Line-Neutral
 Feed applications only
 - 3. NO EQUAL

2.7 POWER APPLICATIONS WITHIN CONTROL PANELS, TWO (TYPE 3) OR FOUR POLE (TYPE 2)

- A. Suppressor shall be a modular two or four DIN rail mounted device built in thermoplastic enclosure, using metal oxide and a gas discharge tube technology;
- B. Suppressor shall provide for both common and differential mode protection;
- C. Suppressor shall be a series device with input and output terminals (no additional terminal blocks) with built in overload protection for the MOV circuit which will disconnect without interrupting the control circuit;
- D. Suppressor shall provide unpowered visual status indication;
- E. Suppressor shall include a set of unpowered Form C contacts to provide a suppressor status signal to a remote location;
- F. Acceptable Power Applications Within Control Panels, Two (Type 3) Or Four Pole (Type 2) Manufacturers.
 - 1. DEHN, INC.
www.dehn-usa.com
 DEHNrail®
 Part No. 953 206 DR M 2P 30 FM;
 Part No. 953 209 DR M 2P 150 FM;
 DEHNguard®
 Part No. 952 307 DG M WE 600 FM;

Part No. 952 313 DG M TNC 150 (1Ø, 110/240VAC, 3-wire grounded neutral service);
 24VDC Applications;
 110VAC Applications;
 480VAC Applications;
 L3 wire to Neutral; L1 & L2 wired to the two hot wires and Ground wired to ground;
 DEHN Engineered Solution DG M WE 600 ENC - Part #999-500; Size: 4.44-inch W x 7.09-inch L x 4.33-inch H; Conduit Fitting: ¾-inch watertight Meyer's hub; Enclosure: NEMA 4X; IP65; Polycarbonate, Weight: ≈ 5-lbs; \$330 each;

2. NO EQUAL

2.8 SERVICE ENTRANCE MAIN DISCONNECT

- A. Suppressor shall be a modular two or four DIN rail mounted device built in thermoplastic enclosure, using metal oxide and a gas discharge tube technology;
- B. Suppressor shall provide for both common and differential mode protection;
- C. Suppressor shall be a series device with input and output terminals (no additional terminal blocks) with built in overload protection for the MOV circuit which will disconnect without interrupting the control circuit;
- D. Suppressor shall provide unpowered visual status indication; green means "Good", red means "replace module";
- E. Suppressor shall include a set of unpowered Form C contacts to provide a suppressor status signal to a remote location;
- F. Suppressor shall be mounted in a NEMA 4X (IP65) Enclosure per Manufacturer recommendations;
- G. Acceptable Service Entrance Main Disconnect SPD Manufacturers;
 - 1. DEHN, INC.
www.dehn-usa.com
 DEHNguard® modular
 Part No. 908 319, DG MU 3PY 480 3W+G R – 277/480VAC, Wye;
 Part No. 908 348, DG MU 3PH 240 4W+G R – 240VAC, Delta;
 Part No. 908 355, DG MU 3PD 480 3W+G R – 480/480VAC, Delta;
 DEHNslac NEMA 4X (IP65) Enclosure Part No. 999 995;
 For use at Lift Stations Duplex/Triplex Service Entrance Main Disconnect;
 - 2. NO EQUAL

2.9 SERVICE ENTRANCE SWITCHBOARDS, FRONT CONNECTED DISTRIBUTION SWITCHBOARDS, MOTOR CONTROL CENTERS, METAL-ENCLOSED SWITCHGEAR AND ALL PANELBOARDS

- A. All Service Entrance Switchboards, Front Connected Distribution Switchboards, Motor Control Centers, Metal-Enclosed Switchgear and all Panelboards provided under this contract shall be protected using Type 1 or Type 2 Integral Bus Mounted SPDs;
- B. SPD shall be ANSI/UL 1449 3rd Edition VZCA or VCZA2 Listed;

- C. SPDs containing SCCRs using upstream overcurrent protection are prohibited;
- D. SPD shall be installed internal to electrical distribution equipment by the electrical distribution equipment Manufacturer;
- E. SPD shall be a self-contained module design;
- F. Each suppression element shall be MOV based;
- G. Each phase of the surge current diversion module shall be protected using surge rated fuses and thermal cutouts;
- H. SPD shall provide surge current diversion paths between each phase conductor and the neutral conductor, between each phase conductor and the ground and between the neutral conductor and ground. For delta configured systems, the SPD shall have components connected between each phase conductor and between each phase conductor and ground.
- I. SPD shall incorporate copper bus bars for the surge current path. Small gauge round wiring or plug-in connections shall not be used in the path for surge current diversion. Surge current diversion module shall be bolted directly to the bus bars of the distribution equipment for reliable low impedance connections;
- J. SPD shall be equipped with on board visual and audible diagnostic monitoring. Indicator lights shall provide full time visual diagnostic monitoring of the operational status of each phase of the surge current diversion module. An amber indicator light will indicate reduced suppression capability. A red indicator light will indicate total loss of suppression capability. A green indicator light will indicate fully operational suppression capability. Audible diagnostic monitoring shall be by way of audible alarm. This alarm shall activate upon a fault condition. An alarm on/off switch shall be provided to silence the alarm. An alarm push to test switch shall be provided.
- K. The SPD diagnostic monitoring device shall be mounted on the front of the panelboard, switchgear compartment, motor control center or enclosure. The diagnostic monitoring circuits shall continually monitor the operational status of the surge current diversion module. A diagnostic system press to test switch shall be provided. A set of Form C dry contacts shall be provided for remote annunciation. No other test equipment shall be required for SPD monitoring or testing before or after installation.
- L. SPD shall have a response time no greater than a ½-nanosecond for any of the individual protection modes.
- M. SPD shall be equipped with the following optional items:
 - 1. Event surge counter shall be located on the front cover of the panelboard. The counter shall be equipped with a manual reset and a battery to retain memory upon loss of AC power;
 - 2. Remote monitor panel with indicating lights and audible alarm for mounting in a remote location;
- N. Acceptable Service Entrance Switchboards, Front Connected Distribution Switchboards, Motor Control Centers, Metal-Enclosed Switchgear and All Panelboards Manufacturers
 - 1. EATON CORPORATION

- www.eaton.com
CUTLER-HAMMER® SPD Series Integrated Unit with Remote Monitor;
SPD with Surge Counter;
- 2. www.sea.siemens.com
Sentron® Transient Protection System TPS3 with Remote Monitor;
TPS3 with Surge Counter;

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All protectors and surge suppression devices (SPDs) shall be installed per Manufacturer's recommendations and practice.

3.2 MEASUREMENT, CONTROL, INSTRUMENTATION AND FIELD BUS COMMUNICATION APPLICATIONS WITHIN A CONTROL PANEL

- A. Complete protector (base & pluggable protector module) shall be installed for all digital, analog and field bus communication conductors entering and/or leaving the control panel to provide maximum protection of the control panel or field device;

3.3 IEEE 802.3 ETHERNET COMMUNICATION APPLICATIONS IN CONTROL PANELS

- A. Suppressor shall be installed for every Ethernet device, exposed to the elements such as a network camera or Wi-Fi Antenna, CAT5/6 cable network connection (media converter, switch, hub, PC, etc.) to provide maximum protection;

3.4 COAXIAL COMMUNICATION APPLICATIONS IN CONTROL PANELS

- A. Suppressor shall be installed for every device, exposed to the outdoors through the use of an external antenna;

3.5 MEASUREMENT, CONTROL AND INSTRUMENTATION APPLICATIONS IN EXPOSED OUTDOOR ENVIRONMENTS

- A. Suppressor shall be installed at the location of the field sensor, transmitter or device to provide maximum protection; Appropriate suppressor, based on application and device being protected, shall be used;

3.6 POWER APPLICATIONS WITHIN CONTROL PANELS, SINGLE POLE

- A. Install direct-wired branch circuit suppressor at each end of the power supply conductors of each of the following devices:
 - 1. Fire alarm panel;
 - 2. Intercommunications master panel;
 - 3. Building management system panel;
 - 4. Security system panel;
 - 5. Power supply to the main telephone panel;

6. Television system cable entrance, exterior antenna lead, and amplifier panel;
7. All wall outlets which are indicated as supplying computers;
8. Power supply to instrumentation and control system cabinets;
9. PLCs;
10. RTUs;

3.7 POWER APPLICATIONS WITHIN CONTROL PANELS, TWO OR FOUR POLE

- A. Install direct-wired branch circuit suppressor at each end of the power supply conductors of each multi-phase control panel(s);

3.8 SERVICE ENTRANCE MAIN DISCONNECT

- A. Install at electrical service entrance main disconnect panel. Service entrance suppressors shall be installed on the load side of the main circuit breaker.

3.9 SERVICE ENTRANCE SWITCHBOARDS, FRONT CONNECTED DISTRIBUTION SWITCHBOARDS, MOTOR CONTROL CENTERS, METAL-ENCLOSED SWITCHGEAR AND ALL PANELBOARDS

- A. Primary Service Installations
 1. Provide at each electrical service entrance and at indicated equipment. Service entrance suppressors shall be installed on the load side of the services disconnecting means and protected with a circuit breaker.
 2. Provide separate suppressor elements between each phase and ground, between each phase and neutral, and between neutral and ground, except when the suppressor is connected to service entrance equipment;
- B. Secondary Service Panels
 1. Provide at each panel board, motor control center (MCC) and at indicated equipment. Install on line side of the panel and protected with a circuit breaker.
 2. Provide suppressor elements between each phase
 3. Provide suppressor element between each phase and ground, between each phase and neutral, and between neutral and ground;

3.10 ADJUSTING AND CLEANING

- A. The protectors and SPDs shall be adjusted accordingly per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.

3.11 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.12 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup

- service for all SPDs.
- B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- C. Verify that all SPDs are installed and connected according to the Contract Documents;
- D. D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
- E. Verify that wiring installation complies with requirements in Division 16 Sections.
- F. Complete installation and startup checks according to Manufacturer's written instructions.

3.13 WARRANTY

- A. At a minimum, all protectors, surge suppressor devices and supporting components shall be guaranteed to be free of defects in materials and workmanship for a minimum of five (5) years from the date of Substantial Completion. Protectors, SPDs or components damaged prior to Substantial Completion shall be replaced at no cost to the City.

End of Section

REMOVAL OF EXISTING EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes the requirements for removal, disposal and transfer of existing equipment.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
 - 1. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
 - 2. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
- D. A list of all equipment to be delivered to the City shall be provided prior to Substantial Completion. All other equipment and/or materials shall be disposed of by the Contractor without additional costs to the City;

1.4 QUALITY ASSURANCE (NOT USED)

1.5 DELIVERY, STORAGE AND HANDLING (NOT USED)

PART 2 - PRODUCTS

2.1 SALVAGEABLE EQUIPMENT AND MATERIALS

- A. All equipment and materials which are removed through modifications and demolition shall remain the property of the City.
- B. Carefully remove any salvageable equipment and materials from the site and suitably place as directed by the City.
- C. The City may include a list of materials and/or equipment that shall modify this requirement.

PART 3 - EXECUTION (NOT USED)

End of Section

ELECTRICAL TESTING (TOOLS & TRAINING)

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes the minimum testing and documentation requirements that shall be performed, documented, certified and provided to the Engineer and City for acceptance of the electrical wiring, equipment and installation as shown on the Contract Drawings and specified herein.
- B. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements
 - 2. Division 2 – Site Work
 - 3. Division 3 – Concrete
 - 4. Division 11 – Equipment
 - 5. Division 13 – Special Construction
 - 6. Division 15 – Mechanical
 - 7. Division 16 – Electrical

1.2 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards.
 - 1. American National Standards Institute (ANSI) 450 Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations.
 - 2. ANSI C2 - National Electrical Safety Code.
 - 3. ANSI C37.20.1 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
 - 4. ANSI C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear.
 - 5. ANSI C37.20.3 - Metal-Enclosed Interrupter Switchgear.
 - 6. ANSI C62.33 - Standard Test Specifications for Varistor Surge-Protective Devices.
 - 7. American Society for Testing and Materials (ASTM) D665 - Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
 - 8. ASTM DS77 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - 9. ASTM D923 - Standard Test Method for Sampling Electrical Insulating Liquids.
 - 10. ASTM D924 - Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - 11. ASTM D971 - Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method.

12. ASTM D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
13. ASTM D1298 - Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
14. ASTM D1500 - Standard Test Method for ASTM Color of Petroleum Products.
15. ASTM D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
16. ASTM D1533 - Standard Test Methods for Water in Insulating Liquids.
17. ASTM D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
18. ASTM D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop- Weight Method.
19. Institute of Electrical and Electronics Engineers (IEEE) 43 - Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
20. IEEE 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.
21. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
22. IEEE 95 - Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
23. IEEE 118 - Standard Test Code for Resistance Measurement.
24. IEEE 400 - Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
25. National Electrical Manufacturers Association (NEMA) AB 4 Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
26. National Fire Protection Association (NFPA) 70 – National Electric Code (NEC®).
27. NEMA PB 2 - Dead-front Distribution Switchboards.
28. NEMA WC 7 - Cross-Linked-Thermosetting-Polyethylene-Wire and Cable for the Transmission and Distribution of Electrical Energy.
29. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
30. International Electrical Testing Association (NETA) ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
31. NFPA 70E® - Electrical Safety in the Workplace.

1.3 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no

larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. 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 for.
- E. Quality Control Submittals: Submit within 30 days after completion of test:
 - 1. Test or inspection reports and certificates for each electrical item tested.
- F. Contract Closeout Submittals:
 - 1. Operation and Maintenance Data:
 - a. In accordance with Section 01730 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.

1.4 QUALITY ASSURANCE

- A. Testing Firm Qualifications:
 - 1. Corporately and financially independent organization functioning as an unbiased testing authority
 - 2. Professionally independent of Manufacturers, suppliers, and installers, of electrical equipment and systems being tested
 - 3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems
 - 4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET), or International Electrical Testing Association and having a minimum of 5 years testing experience on similar projects
 - 5. Technicians certified by NICET or NETA
 - 6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one non-certified assistant or apprentice
 - 7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken and opinions
 - 8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full Member Company of International Electrical Testing Association

- 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.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
- B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 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

3.1 GENERAL

- A. Tests specified in this section are to be performed in accordance with the requirements of Section 01650 Facility Startup/Checkout.
- 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 any unevenness
- 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 NEC®
- 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:
 - a. Provide matching paint and touch up scratches and marks
 - b. 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.

3.2 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 draw-out 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. The 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. 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° 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.
 - e. Current Injection Tests:
 - f. For entire current circuit in each section.
 - g. Secondary injection for current flow of 1 ampere.
 - h. Test current at each device.
3. 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.
4. Operational Test:
 - a. Initiate control devices.
 - b. Check proper operation of control system in each section.

3.3 DRY TYPE TRANSFORMERS

- A. Visual and Mechanical Inspection:
 1. Physical and insulator damage.
 2. Proper winding connections.
 3. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by Manufacturer.
 4. Defective wiring.
 5. Proper operation of fans, indicators, and auxiliary devices.
 6. Removal of shipping brackets, fixtures, or bracing.
 7. Free and properly installed resilient mounts.
 8. Cleanliness and improper blockage of ventilation passages.
 9. Verify that tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
 10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.2.3 for each Winding-to-winding and Winding-to-ground;
 - b. Ten-minute test duration with resistances tabulated at 30 seconds, 1 minute and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 7.2.4.
 - d. Temperature corrected insulation resistance values equal to, or greater than, Ohmic values established by Manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by Manufacturer.

3.4 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.

3.5 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 micro-ohms across each switchblade and fuse holder.
 - b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.6 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

- A. General: Inspection and testing limited to circuit breakers rated ≥ 70 amperes and to motor circuit protector breakers rated ≥ 50 amperes.
- 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 °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 micro-ohms 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.

3.7 INSTRUMENT TRANSFORMERS

- A. Visual and Mechanical Inspection:
 - 1. Visually Check Current, Potential, and Control Transformers For:
 - a. Cracked insulation.
 - b. Broken leads or defective wiring.
 - c. Proper connections.
 - d. Adequate clearances between primary and secondary circuit wiring.
 - 2. Verify Mechanically That:
 - a. Grounding and shorting connections have good contact.
 - b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
 - 3. Verify proper primary and secondary fuse sizes for potential transformers.
- B. Electrical Tests:
 - 1. Current Transformer Tests:
 - a. Insulation resistance test of transformer and wiring-to-ground at 1,000-Volts dc for 30 seconds.
 - b. Polarity test.
 - 2. Potential Transformer Tests:
 - a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for 1 minute on Winding-to-winding and Winding-to-ground.
 - b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.

3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.8 METERING

- A. Visual and Mechanical Inspection:
 1. Verify meter connections in accordance with appropriate diagrams.
 2. Verify meter multipliers.
 3. Verify that meter types and scales conform to Contract Documents.
 4. Check calibration of meters at cardinal points.
 5. Check calibration of electrical transducers.

3.9 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.

3.10 GROUND FAULT SYSTEMS

- A. Inspection and Testing Limited To:
 1. Zero sequence grounding systems.
 2. Residual ground fault systems.
- B. Visual and Manual Inspection:
 1. Neutral Main Bonding Connection to Assure:
 - a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
 - b. Ground strap sensing system is grounded through sensing device.
 - c. Neutral ground conductor is solidly grounded.

2. Verify that control power has adequate capacity for system.
3. Manually Operate Monitor Panels For:
 - a. Trip test.
 - b. No trip test.
 - c. Non-automatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.
- C. Electrical Tests:
 1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 mega-ohm.
 2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
 3. Test relay timing by injecting 300 percent of pickup current, or as specified by Manufacturer. Relay operating time in accordance with Manufacturer's time-current characteristic curves.
 4. Test system operation at 55 percent rated control voltage, if applicable.
 5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.11 AC INDUCTION MOTORS

- A. General: Inspection and testing limited to motors rated 5 horsepower and larger.
- B. Visual and Mechanical Inspection:
 1. Proper electrical and grounding connections.
 2. Shaft alignment.
 3. Blockage of ventilating air passageways.
 4. Operate Motor and Check For:
 - a. Excessive mechanical and electrical noise.
 - b. Overheating.
 - c. Correct rotation.
 - d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.
 - e. Excessive vibration.
 5. Check operation of space heaters.
- C. Electrical Tests:
 1. Insulation Resistance Tests:
 - a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
 - i. Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - ii. Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.

- b. Insulation resistance values equal to, or greater than, ohmic values established by Manufacturers.
- 2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
- 3. Insulation resistance test on insulated bearings in accordance with Manufacturer's instructions.
- 4. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amperes.
- 5. Overpotential Tests:
 - a. Applied dc voltage in accordance with IEEE 95.
 - b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.
 - c. Test results evaluated on pass/fail basis.

3.12 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. Medium and low voltage disconnect switches
 - 3. Transfer switches
 - 4. Engine-generators
- 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 °C temperature difference between subject area and reference point of 30 °C
- G. Temperature Gradients Of:
 - 1. 3 °C to 7 °C indicates possible deficiency that warrants investigation.
 - 2. 7 °C to 15 °C indicates deficiency that is to be corrected as time permits.
 - 3. 16 °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 °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

SECTION 13300

PROCESS INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.01 SCOPE

- A. A single pre-approved Instrumentation System Supplier (ISS) shall furnish services and equipment defined herein and in other Specification sections as listed below under Related Work, and as shown on the Contract Drawings. Owner criteria for pre-approval:
 - 1. The ISS shall be an experienced, competent, qualified firm and pre-approved by the Owner's Industrial Automation Manager.
 - 2. The ISS shall have a minimum of five (5) years' experience in the last seven (7) years using SIEMENS SIMATIC S7-300/400 Hardware components, SIEMENS SIMATIC STEP7 PROFESSIONAL (STL, LAD and SCL as a minimum) and SIEMENS SIMATIC WinCC HMI System (Server, Redundancy, Logon, Load Balancing, Connectivity, Graphics, Audit, Web Navigator, Archiving, Alarming) development software.
 - 3. The ISS shall detail the municipal wastewater projects the company has completed with a minimum of ten (10) current, complete references (municipal name, individual name and title, and telephone number).
- B. The ISS shall provide all materials, equipment, labor and services required to achieve a fully integrated and operational system. The ISS shall design and coordinate the instrument and control system for proper operation with related equipment and materials furnished by other suppliers under other sections of these Specifications and with related existing equipment.
- C. Any control programming modifications of the existing or new PLCs and HMI shall be performed by the Owner.
- D. Auxiliary and accessory devices necessary for system operation or performance, such as transducers or relays to interface with existing equipment or equipment provided by other suppliers under other Sections of these Specifications, shall be included whether they are shown on the instrument drawings or not.
- E. Substitutions on functions or type of equipment specified will not be acceptable. In order to ensure the interchangeability of parts, the maintenance of quality, the ease of interfacing between the various subsystems, and the establishment of minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained. In order to ensure compatibility between all equipment, it shall be the responsibility of the ISS to coordinate all interface requirements with mechanical and electrical system suppliers and furnish any signal isolation devices that might be required.

- F. Equipment shall be fabricated, assembled, installed, and placed in proper operating condition in full conformity with detailed Drawings, Specifications, engineering data, instructions and recommendations of the equipment Manufacturer as approved by the Engineer.
- G. To facilitate the Owner's future operation and maintenance, products shall be of the same major instrumentation manufacturer, with panel-mounted devices of the same type and model as far as possible.
- H. All work shall be coordinated with the Owner's Operations personnel to minimize impact on its daily operation.
- I. All equipment and installations shall satisfy applicable Federal, State, and local codes.
- J. Supplementing this Section, the Contract Drawings and the related Specification sections provide additional details showing panel elevations, instrument device schedules, functional requirements of the system, and interaction with other equipment.
- K. All materials, equipment, labor, and services necessary to achieve the monitoring and control functions described herein shall be provided in a timely manner such that the monitoring and control functions are available when the equipment is ready to be placed into service.
- L. Unless otherwise indicated or specified on the Contract Drawings:
 - 1. For non-corrosive, air-conditioned spaces, provide instrumentation in NEMA 12 enclosures;
 - 2. For corrosive and/or outdoor locations, provide NEMA 4X enclosures with sunshields and transmitter display sun guard;
- M. Related Work Specified Elsewhere (if included):
 - 1. Division 1 – General Requirements;
 - 2. Division 2 – Site Work;
 - 3. Division 3 – Concrete;
 - 4. Division 11 – Equipment;
 - 5. Division 13 – Special Construction;
 - a. Section 13310 - Programmable Logic Controller (PLC) and Digital Equipment;
 - b. Section 13315 - Field Instrumentation;
 - 6. Division 15 – Mechanical;
 - 7. Division 16 – Electrical;
 - a. Section 16709 - Protectors and Surge Protection Devices (SPDs);

- b. Section 16120 - Wires And Cables – 600-Volt And Less;

1.02 REFERENCES

- A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:
 - 1. American Society for Testing and Materials (ASTM) A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service;
 - 2. American Petroleum Institute (API) Recommended Practice 550 – Instrumentation and Control Manual for Refinery;
 - 3. American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA)/Telecommunications Industry Association (TIA) Standards 568B - Commercial Building Telecommunications Cabling Standard:
 - a. TIA/EIA-568-B.1 General Requirements;
 - b. TIA/EIA-568-B.2 Balanced Twisted Pair Cabling Components;
 - c. TIA/EIA-568-B.3 Optical Fiber Cabling Components;
 - 4. ANSI/TIA/EIA-569-B - Commercial Building Standard for Telecommunications Pathways and Spaces;
 - 5. Instrumentation, Systems and Automation Society (ISA) 5.1 - Instrumentation Symbols and Identification;
 - 6. ANSI/TIA/EIA-598-A - Optical Fiber Cable Color Coding;
 - 7. ISA 5.2 - Binary Logic Diagrams for Process Operations;
 - 8. ISA 5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems;
 - 9. ISA 5.4 - Instrument Loop Diagrams;
 - 10. ISA 5.5 - Graphic Symbols for Process Displays;
 - 11. American National Standards Institute (ANSI) X3.5 - Flowchart Symbols and Their Usage in Information Processing;
 - 12. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
 - 13. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
 - 14. NECA 301 - Standard for Installing and Testing Fiber Optics;
 - 15. National Electrical Manufacturers Association (NEMA) 250 - Enclosures for Electrical Equipment (1000-Volts Maximum);
 - 16. National Fire Protection Association® (NFPA®) 70 – National Electric Code® (NEC®);

17. NEC® Article 770 – Optical Fiber Cables and Raceways;
18. NEC® Article 800 – Communications Circuits;
19. NFPA® 70E® - Electrical Safety in the Workplace;
20. NFPA® 72 - National Fire Alarm Code;
21. Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
22. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
23. UL 508A - Industrial Control Equipment;
24. UL 698A - Industrial Control Panels Relating to Hazardous (Classified) Locations;

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders (overall dimensions no greater than 9-inch x 11-½-inch), all materials indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. Shop Drawings shall fully demonstrate that the equipment and services to be furnished will comply with the provisions of these Specifications and shall provide a true and complete record of the equipment as manufactured and delivered.
- E. The ISS shall develop, with guidance from the Owner, all of the following as separate submittals:
 1. Field Instrumentation;
 2. Digital System Hardware and Control Panels;
 3. Input/output (I/O) Drawings;
 4. PLC & HMI Software Programming (if included);
 5. Testing;
 6. Training;
 7. Spares, Expendables and Test Equipment;

- F. Instrumentation Submittal - This submittal shall provide complete documentation of all field instruments, panel components and other instrument and control equipment not specified to be submitted elsewhere.
1. Provide data sheets for each component listing all model numbers, optional, and ancillary devices that are being provided. The data sheets shall be provided with an index and proper identification and cross-referencing. They shall include but not be limited to the following information:
 - a. Plant Equipment Number and ISA tag number per the Loop Diagrams;
 - b. Product (item) name used herein and on the Contract Drawings;
 - c. Manufacturer's complete model number;
 - d. Location of the device;
 - e. Input/output characteristics;
 - f. Range, size and graduations;
 - g. Physical size with dimensions, enclosure NEMA classification and mounting details;
 - h. Construction materials of all components;
 - i. Instrument or control device sizing calculations where applicable;
 - j. Certified calibration data on all flow metering devices;
 2. Provide equipment specification sheets that shall fully describe the device, the intended function, how it operates, and its physical, environmental and performance characteristics. Each data sheet shall have appropriate cross references to loop or equipment identification tags. At a minimum, the specification sheets shall include the following:
 - a. Dimension, rigid clearances;
 - b. Mounting or installation details;
 - c. Connections;
 - d. Electrical power or air requirements;
 - e. Materials of construction;
 - f. Environmental characteristics;
 - g. Performance characteristics;
 3. The submittal shall also contain all planning information, site preparation instructions, grounding and bonding procedures, cabling diagrams, plug identifications, safety precautions or guards, and equipment layouts in order to enable the ISS to proceed with the detailed site preparation for all equipment.

- G. Digital System Hardware and Control Panels Submittal - This submittal shall provide complete documentation of the proposed hardware (PLCs, computers, communications equipment, peripherals, etc.) and control panels, consoles, and enclosures. The submittal shall be developed in coordination with the Owner. The submittal shall include:
1. A complete system block diagram(s) showing in schematic form, the interconnections between major hardware components such as: control centers, panels, power supplies, consoles, computer and peripheral devices, telemetry equipment, local digital processors and like equipment. The block diagram shall reflect the total integration of all digital devices in the system and shall reflect any man/machine interface locations. All components shall be clearly identified with appropriate cross-references to the location of each. The diagram shall reference all interconnecting cabling requirements for digital components of the system including any data communication links.
 2. Detailed drawings covering control panels, consoles and/or enclosures which shall include:
 - a. Cabinet assembly and layout (front & rear) drawings to scale;
 - b. Fabrication and painting specifications;
 - c. Color selection samples for selection by the Engineer.
 - d. Panel wiring diagrams showing all power connections to equipment within and on the enclosure, combined panel power draw requirements (volts, amps), breaker sizes, fuse sizes, and grounding. This wiring diagram shall be in ladder logic format and shall reference the appropriate Loop Drawing for continuations or details where required. Show all wire numbers and terminal block designations.
 3. The Digital System Hardware submittal shall also contain all planning information, site preparation instructions, grounding and bonding procedures, cabling diagrams, plug identifications, safety precautions or guards, and equipment layouts in order to enable the ISS to proceed with the detailed site preparation for all equipment.
 4. The ISS shall provide fiber optic power budget for each cable run in excess of 500 feet. Cable budget shall include transmitter power, receiver sensitivity, connector losses, cable losses and a 3-db aging margin. Fiber optic transmission line shall maintain a minimum of 3-db safety margin.
- H. I/O Drawings Submittal - Provide detailed I/O (loop) diagrams on a single 11-inch x 17-inch sheet for each monitoring or control loop. The loop diagram shall show all components of the loop both analog, digital, and discrete including all relays, switches, dropping resistors, etc. which are being provided for proper operation. Loop numbers used shall correspond to the loop numbers indicated in the contract documents. The format shall be the ISA Standard for Instrument Loop Diagrams (ISA S5.4) plus the following requirements:
1. On each diagram present a tabular summary of (1) the output capability of the transmitting instrument, (2) the input impedance of each receiving instrument, (3)

an estimate of the loop wiring impedance based on wire sizes and approximate length used, (4) the total loop impedance, (5) reserve output capacity;

2. Show all interconnecting wiring between equipment; panels, junction boxes/termination cabinets and field mounted components, whether existing or new; The diagrams shall show all components and panel terminal board identification numbers and all wire numbers;
3. Indicate the location of each device;
4. Show instrument description showing type, Manufacturer, model number, range, set points, and operation (e.g. fail open, open on power supplied, normally closed, etc.) as applicable;
5. Show all instrument loop power or instrument air requirements back to termination on terminal block or bulkhead, fuse block (including fuse size), etc., as applicable;
6. Show all grounding points within cabinets and panels and identify the connection point of individual components;

I. Software Programming Submittal -

1. Software Programming for both PLC and HMI screens shall be done by the Owner, unless otherwise noted on plans;

J. Testing Submittals –

1. The test plan shall be submitted after the Owner and/or Engineer have approved all hardware submittals.
2. The test plan shall demonstrate that the ISS has designed and configured a system that meets the design specifications. The documents for the test plan shall be structured so that the Owner understands what the inputs are, what the predicted outputs should be and what the actual outputs are. The test plan should have sign off and date block for the ISS, the Engineer and the Owner.
3. The complete test plan should include as a minimum descriptions for the following:
 - a. System hardware and software summary;
 - b. A schedule for the testing describing the specific tasks to be performed and the time allotted for each; If the Owner is performing the PLC and HMI Programming tasks, these tasks are estimated to be three (3) weeks of effort after all individual devices are visible & accessible on their respective network and they work properly in Hand/Local.
 - c. Communications test to the various PLCs for Discrete and Analog I/O data transfer.
 - d. 100% I/O point test including all spare points based upon the previously submitted System I/O list;

4. Test Procedures - Submit the procedures to be followed during the test. Procedures shall include test descriptions, forms, and checklists to be used to control and document the required tests.
 - a. Preliminary test procedure submittals - Prior to the preparation of the detailed test procedures, submit outlines of the specific proposed tests. Submittals shall include examples of the proposed forms and checklists.
 - b. Test Procedure Submittals - After the preliminary test procedure submittals have been reviewed by the Engineer and returned stamped "Approved", submit the proposed detailed test procedures. Testing may not be started until all Testing Submittals have been approved.
5. Test Documentation - Submit a copy of the signed off test procedures upon completion of each required test.

K. Training Submittals -

1. Preliminary Training Plan - Within 90 days of contract award to the ISS, submit an overview of the proposed training plan. The Engineer will review the preliminary training plan submittal with the Owner. This overview shall include, for each course proposed:
 - a. An overview of the training plan explaining why specific courses are proposed;
 - b. Course title and objectives;
 - c. Prerequisite training and experience of attendees;
 - d. Recommended types of attendees;
 - e. Course Content that includes a topical outline;
 - f. Course Duration;
 - g. Course Location (Training center or job site);
 - h. Course Format (Lecture, laboratory demonstration, etc.);
2. Final Training Plan - Upon receipt of the Owner and Engineer's comments on the preliminary training plan, submit the specific proposed training plan. The training plan shall include:
 - a. Definitions of each course;
 - b. Specific course attendance;
 - c. Schedule of training courses including dates, duration, and locations of each class;
 - d. Resumes of the instructors who will actually conduct the training;

L. Spares, Expendables, and Test Equipment Lists Submittal -

1. This submittal shall include for each Subsystem:
 - a. A list of, and descriptive literature for, spares, expendables, and test equipment as specified in Instrumentation Specifications.
 - b. A separate list of, and descriptive literature for, additional spares, expendables, and test equipment recommended by the ISS.
 - c. Unit and total costs for the additional spare items recommended for each subsystem.
 - d. Provide storage instructions for all spare parts.

1.04 QUALITY ASSURANCE

- A. The ISS shall have a minimum of ten (10) years consecutive experience producing similar process instrumentation and controls equipment.
- B. B. The ISS shall be UL 508A & UL 698A Listed; All panels shall be built by a UL 508A shop with each panel labeled and registered accordingly; All equipment furnished shall have a UL testing certification attached;
- C. The ISS shall perform all work necessary to select, furnish, install, connect, and place into operation all hardware specified within this Division;
- D. Actual installation of the system need not be performed by the ISS's employees; however, the ISS shall be responsible for the on-site technical supervision of the installation;
- E. The ISS shall furnish equipment that is the product of one Manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one Manufacturer;

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver all process instrumentation and controls equipment in factory labeled packages.
- B. Handling and shipment of the equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in controller and if necessary, apply temporary heat where required to obtain suitable service conditions.

D. Shipping Precautions

1. After completion of shop assembly, factory test, and approval, all equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing and handling at job site.
2. Special instructions for proper field handling, storage and installation required by the manufacturer for proper protection, shall be securely attached to the packaging for each piece of equipment prior to shipment. The instructions shall be stored in re-sealable plastic bags or other acceptable means of protection.
3. None of the control equipment shall be shipped to the site until the room(s) is environmentally suitable.

E. Identification

1. Each component shall be tagged to identify its location, tag number and function in the system. Identification shall be prominently displayed on the outside of the package.
2. A permanent plastic tag, black letters on white background, shall be firmly attached and permanently and indelibly marked with the instrument tag number, as given in the Contract Drawings, to each piece of equipment supplied.

F. Storage

1. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters including all equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be replaced by the ISS at his cost and expense.

1.06 SPARE PARTS

- A. One year's supply of items recommended by the Manufacturer of the equipment for each component in this Specification. A statement from the Manufacturer of each instrument, either standard published product literature or a written statement on their letterhead, shall be provided which states the recommended spare parts for one year's operation for each instrument provided.
- B. Provide other spare parts as indicated on the individual device specifications.
- C. The spares listed above shall be packed in a manner suitable for long term storage and shall be adequately protected against corrosion, humidity and temperature.
- D. Provide one quart of touch up paint, in one pint containers, for each type and color used for all cabinets, panels, consoles, etc., supplied under all related Specification sections.

1.07 PROJECT/SITE REQUIREMENTS

- A. Environmental Requirements. Indoor, non-process areas require NEMA Type 12 Type 316 stainless steel enclosures. All other areas require NEMA Type 4X 316 stainless steel enclosures. Refer to Division 16 for area environmental hazardous classifications. Outdoor areas require sun shields.
- B. Elevation. Equipment shall be designed to operate at a ground elevation of approximately 15 to 20 feet above mean sea level. Equipment below grade shall be NEMA Type 4X.
- C. Temperature. Indoor area equipment shall be suitable for 50 to 104 °F (10 to 40 °C) ambient. Outdoor area equipment shall be suitable for 86 to 122 °F (30 to 50 °C) ambient. Storage temperatures will range from 32 to 122 °F (0 to 50 °C) ambient. Additional cooling or heating shall be furnished if required by the equipment furnished.
- D. Relative Humidity. Air-conditioned area equipment shall be suitable for 20 to 80 percent relative, non-condensing humidity. All other equipment shall be suitable for 0 to 100 percent relative, condensing humidity.
- E. Power Supply. 120VAC sources of electric supply will be unregulated industrial panel boards;

1.08 COORDINATION MEETINGS

- A. The ISS 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 ISS Project Engineer and the Electrical Subcontractor, etc.).
- B. The meeting shall be held in advance of the first ISS shop drawing submittal. The purpose of the meeting shall be for the ISS to: summarize their understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery milestone dates; provide a forum for the ISS, Engineer, and Owner to coordinate hardware and software related issues; and request any additional information required from the Engineer and/or Owner. Also, the ISS shall coordinate conduit and wire requirements for all instrumentation and controls with the Electrical Subcontractor before electrical work is begun. The ISS 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 ISS. 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. D. The third meeting shall be held one month prior to factory acceptance testing. The purpose of this third meeting is to discuss any remaining coordination requirements.

1.09 FINAL SYSTEM DOCUMENTATION

- A. Prior to final acceptance of the system and Owner training, operating and maintenance manuals covering instruction and maintenance on each type of equipment shall be furnished on electronic media (book-marked Adobe Acrobat PDF files and all drawings in the latest AutoCAD format) and hard copy.
- B. The instructions shall be bound in three ring binders with Drawings reduced or folded for inclusion and shall provide at least the following as a minimum:
 - 1. A comprehensive index;
 - 2. A complete "As Constructed" set of approved shop Drawings;
 - 3. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data;
 - 4. Full specifications on each item;
 - 5. System schematic drawings "As Constructed", illustrating all components, piping and electrical connections of the systems supplied under this Section;
 - 6. Detailed service, maintenance and operation instructions for each item supplied;
 - 7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures;
 - 8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic Drawings and instructions;
 - 9. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier;
- C. The final documentation shall be new documentation written specifically for this project but may include standard and modified standard documentation. Modifications to existing hardware or software manuals shall be made on the respective pages or inserted adjacent to the modified pages. All standard documentation furnished shall have all portions that apply clearly indicated. All portions that do not apply shall be lined out.
- D. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

- E. If the ISS transmits any documentation or other technical information that he considers proprietary, such information shall be designated. Documentation or technical information that is designated, as being proprietary, will be used only for the design, construction, operation, or maintenance of the System and, to the extent permitted by law, will not be published or otherwise disclosed.
- F. The requirements for the final documentation are as follows:
1. As built documentation shall include all previous submittals, as described in this Specification, updated to reflect the as built system. Any errors in or modifications to the System resulting from the Factory and/or Field Acceptance Tests shall be incorporated in this documentation.
 2. The Hardware Maintenance Documentation shall describe the detailed preventive and corrective procedures required to keep the System in good operating condition. Within the complete Hardware Maintenance Documentation, all hardware maintenance manuals shall make reference to appropriate diagnostics, where applicable, and all necessary timing diagrams shall be included. A maintenance manual or a set of manuals shall be furnished for all delivered hardware, including peripherals. The Hardware Maintenance Documentation shall include, as a minimum, the following information:
 - a. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
 - b. Preventative Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines and the adjustments necessary for periodic preventive maintenance of the System;
 - c. Corrective Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction;
 - d. Parts Information - This information shall include the identification of each replaceable or field repairable module. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross references between the ISS's part number and Manufacturer's part numbers shall be provided;
- G. The ISS shall submit the final documents after the review and approval of the Engineer as specified in Section 01730.

PART 2 – PRODUCTS

2.01 GENERAL

A. Type & Ratings

1. All instrumentation supplied shall be of the Manufacturer's latest design and shall produce or be activated by signals that are established standards for the water and wastewater industries;
2. All electronic instrumentation shall be of the solid-state type and shall utilize PROFIBUS® DP™ communications, if available. Those devices that do not support PROFIBUS® DP™ communications shall use linear transmission signals of 4 to 20 mA DC (milli-ampere direct current);
3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals shall be allowed;
4. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Contract Drawings or as required;
5. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Electrical Drawings, to comply with the NEC®;
6. All indicators and recorder read outs shall be linear in process units, unless otherwise noted.
7. All transmitters shall be provided with either integral indicators or conduit mounted indicators in process units, accurate to two (2) percent;
8. Electronic equipment shall be of the Manufacturer's latest design, utilizing printed circuitry and suitably coated to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for their purpose, to assure optimum long-term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions;
9. All equipment, cabinets and devices furnished hereunder shall be heavy duty type, designed for continuous industrial service. The system shall contain products of a single Manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion;
10. The field mounted digital system equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions;
11. All electronic/digital equipment shall be provided with radio frequency interference protection and shall be FCC approved;

B. Electrical

1. All equipment shall be designed to operate on a 60-Hertz alternating current power source nominal 117-volt, plus or minus 10 percent, except where specifically noted. All regulators and power supplied required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied;
2. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.
3. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored;
4. Existing signal and control wiring may be wired through intermediate junction boxes/termination cabinets. Note that all new wiring shall not utilize junction boxes or termination cabinets, but shall be connected directly between PLC or other control system panels, and field devices, equipment or motor control panels;

2.02 LIGHTNING/SURGE PROTECTION

A. General

1. The requirements for lightning and surge protection shall be as specified in Section 16709 - Protectors and Surge Protection Devices (SPDs).

B. Installation

1. The following standards shall be observed:
 - a. All analog (input and output) and digital (input and output) signal lines between an instrument/device and a panel shall be protected individually by surge suppressors at both ends.
 - b. All 120-Volt power to instruments/devices shall be protected with a local surge suppressor mounted at the instrument. Main power to a panel shall be on a circuit breaker.
 - c. All 480-Volt power to devices shall be protected with a local surge suppressor mounted at the device. Main power to a panel shall be on a circuit breaker.
 - d. Communication cable (other than fiber optic) shall be protected at both ends if it runs beyond the walls of a structure.

2.03 INSTRUMENT TUBING & FITTINGS (REF. 13315-2.28.)

- A. All instrument tubing shall be fully annealed ASTM A269 Seamless Type 316 stainless steel free of O.D. scratches having the following dimensional characteristics as required to fit the specific installation:

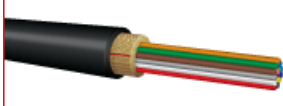
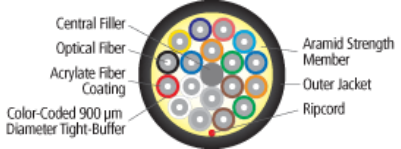
1. ¼-inch to ½-inch O.D. x 0.035-inch wall thickness;
2. 5/8-inch to 1-inch O.D. x 0.049-inch wall thickness;
3. 1-inch O.D. x 0.065-inch wall thickness;
4. 1-¼-inch O.D. x 0.065-inch wall thickness;
5. 1-½-inch O.D. x 0.083-inch wall thickness;
6. 2-inch O.D. x 0.095-inch wall thickness;
7. All instrument process connections shall be ½-inch O.D. Type 316 stainless steel tubing;
8. All instrument air header takeoffs and branch connections less than 2-inch shall be Type 316 stainless steel;
9. All instrument fittings, filters and valves shall be Type 316 stainless steel;
10. All instrument shut off valves and associated fittings shall be supplied in accordance with the specifications and instrument installation details.
11. All tube track shall be installed as per Manufacturer's installation instructions and supported by stainless steel struts;

Item	Manufacturer	Model/Part Number	Comments
B. Acceptable Instrument Tubing & Fittings (ref. 13315-2.28.) MANUFACTURERS			
1.	SWAGELOK® COMPANY www.swagelok.com	Type 316 Stainless Steel Tube, Fittings, Valves, & Other System Components;	
2.	PARKER-HANNIFIN CORPORATION www.parker.com	Type 316 Stainless Steel Tube, Fittings, Valves, & Other System Components;	
C. Acceptable Instrument ¼ or ½-inch NPT Stainless Steel Ball Valve MANUFACTURERS			
1.	CONBRACO INDUSTRIES www.apollovalves.com	Apollo® Valves Series 76F - Threaded, 2-Piece, Full Port, Stainless Steel Ball Valve;	

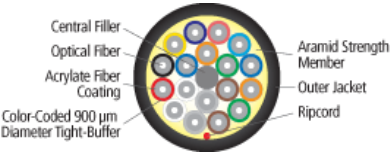
Item	Manufacturer	Model/Part Number	Comments
2.	INLINE INDUSTRIES www.ballvalve.com	201F Series;	
3.	Owner Preapproved Equal		

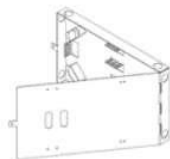
2.04 FIBER-OPTIC CABLE AND ACCESSORIES

- A. Fiber optic cable shall be 6-pair (color coded) cable. Individual fiber colors per TIA/EIA 598-A Fiber Color Code Chart are 1. Blue, 2. Orange, 3. Green, 4. Brown, 5. Gray, 6. White, 7. Red, 8. Black, 9. Yellow, 10. Purple, 11. Rose and 12. Aqua.
- B. Single-Mode (9/125µm) Fiber-Optic Cable
 - 1. OFNP (Optical Fiber Nonconductive Plenum) / FT-6 –rated;
 - 2. UV-resistant;
 - 3. Fully water-blocked indoor/outdoor cable per ANSI/ICEA S-104-696 and NEC® Article 770;
- C. Acceptable Single-Mode (9/125µm) Fiber-Optic Cable MANUFACTURERs

Item	Manufacturer	Model/Part Number	Comments
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com 	FREEDM® One Plenum Cable, Part No. 012E8P-31131-29 Single-mode (OS2); 	012=Fiber count; E=Fiber code – Single mode, OS2, 1310/1383/1550µm wavelength, 0.65 / 0.65 / 0.50 dB/km max. attenuation, 5000m Gig, 10000m 10Gig; 8=FREEDM One cable; P=Indoor/outdoor plenum outer jacket; - 3=Fiber placement; 1=Standard feet length markings; 1=Tensile strength; 31=Performance option code - see above "E"; - 29=No special requirements; \$1.50 per foot;
2.	OPTICAL CABLE CORPORATION www.occfiber.com 	Distribution Series Ultra-Fox™ Plenum Cable, Part No. DX012KSLAYP; 	DX=Distribution Series; 012=Fiber count; K=Indoor/Outdoor Jacket; SLA=Single mode Fiber Type (ITU-T G652.A); 9=250µm fiber with 900µm tight buffer; Y=Yellow Jacket Color; P=Plenum rating; \$1.50 per foot;

Item	Manufacturer	Model/Part Number	Comments
D. Multi-Mode (50/125µm) Fiber-Optic Cable			
			4. OFNP (Optical Fiber Nonconductive Plenum) / FT-6 rated;
			5. UV-resistant;
			6. Fully water-blocked indoor/outdoor cable per ANSI/ICEA S-104-696 and NEC® Article 770;
E. Acceptable Multi-Mode (50/125µm) Fiber-Optic Cable MANUFACTURERS			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	FREEDM® One - Dielectric, OFNP Flame Rating Cable, Part No. 012T8P-31190-29; 	012=Fiber count; T=Fiber code - LANscape® Pretium® 300, 50µm multimode, OM4, 850 / 1300µm wavelength, 2.8 / 1.0 dB/km max. attenuation, 3500 / 500 MHz/km OFL bandwidth, 4700MHz/km bandwidth, 1100 / 600m Gig, 550m 10Gig; 8=FREEDM One cable; P=Indoor/outdoor plenum outer jacket; - 3=Fiber placement; 1=Standard feet length markings; 1=Tensile strength; 90=Performance option code - see above "T"; - 29=No special requirements; \$1.50 per foot;

Item	Manufacturer	Model/Part Number	Comments
2.	OPTICAL CABLE CORPORATION www.occfiber.com	Distribution Series Ultra-Fox™ Plenum Cable, Part No. DX012KALE9QP; 	DX=Distribution Series; 012=Fiber count; K=Indoor/Outdoor Jacket (Fluoropolymer); ALE=50/125µm, 850 / 1300µm, OM4 ISO/IEC 11801, 3.0 /1.0 dB/km max. attenuation, 4700 / 500 MHz/km min. laser bandwidth, 1040 / 600m Gig, 550/300m 10Gig Fiber Type; 9=250µm fiber with 900µm tight buffer; Q=Aqua Jacket Color; P=Plenum rating; \$1.50 per foot;
F. Fiber-Optic Cable Patch Panel 1. Fiber-Optic cable termination interface patch panels shall be provided at all termination points as well as transitions between outdoor and indoor cables.			
G. Acceptable Fiber-Optic Cable Patch Panel & Components MANUFACTURERs (Panels deeper than 12-inches);			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com		\$100 each; \$16 each;  4 - \$160 + \$42 each; 6 - \$200 + \$42 each;

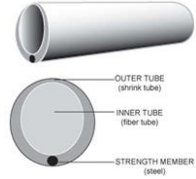
Item	Manufacturer	Model/Part Number	Comments
			12- \$350 + 60 each;  \$20 each; \$83 each SM panel; \$85 each MM panel; 
2.	FIBER INSTRUMENT SALES, INC. www.fiberinstrumentsales.com	Closet Connector Housing (CCH) Panels, 12-Fiber SC, 10 Gig – Aqua, Part No. CCH-CP12-59 SM OS2; Part No. CCH-CP12-E7 MM OM3/4;	 
3.	NO EQUAL		
H. Acceptable Fiber-Optic Cable Patch Panel MANUFACTURERS (Panels 12-inches deep or less)			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	Single Panel Housing, Part No. SPH-01P;	 \$100 each plus panels;

Item	Manufacturer	Model/Part Number	Comments
		Closet Connector Housing (CCH) Panels, 12-Fiber SC, 10 Gig – Aqua, Part No. CCH-CP12-59 SM OS2; Part No. CCH-CP12-E7 MM OM3/4;	CCH Panels: CP12-59 \$ each; CP12-E7 \$80 each;
2.	NO EQUAL		
I. Acceptable Fusion Splice Tray MANUFACTURERs			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	Splice Tray for WCH Series, Part No. M67-110;	 \$45 each;
2.	FIBER INSTRUMENT SALES, INC. www.fiberinstrumentsales.com	PREFORMED LINE PRODUCTS® COYOTE® 12 Count Single Fiber Splice Tray, Part No. 80806033;	 For RUNT, PUP & COYOTE Dome Closures; \$25 each;
3.	Owner Preapproved Equal		
J. Single-Mode Fiber-Optic Cable Terminations (SC & ST)			
K. Acceptable Single-Mode Fiber-Optic Cable Fusion Terminations MANUFACTURERs			
1.	FIBER INSTRUMENT SALES, INC.	12 pack SC/UPC Single mode 900µm,	Includes all industry fiber colors;

Item	Manufacturer	Model/Part Number	Comments
	www.fiberinstrumentsales.com	Part No. SP-12SCUPCBU; 12 pack ST/UPC Single mode 900µm, Part No. SP-12STUPC;	Typical loss .3dB; back reflection 55dB;  \$70 each SC; \$100 each ST;
2.	Owner Preapproved Equal		
L. Acceptable Single-Mode Fiber-Optic Cable Mechanical Terminations MANUFACTURERS			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	SC - UniCam® ST – Not available 	UniCam® SC Connector, single-mode, ceramic ferrule, logo, Housing & Boot; \$20 each;
2.	LEVITON www.leviton.com	SC - Thread-Lock™ ST - Thread-Lock™ 	SC Housing & Boot ST Metal Housing & Boot; \$20 each;
M. Multi-Mode Fiber-Optic Cable Terminations (SC & ST)			
N. Acceptable Multi-Mode Fiber-Optic Cable Fusion Terminations MANUFACTURERS			
1.	FIBER INSTRUMENT SALES, INC. www.fiberinstrumentsales.com	12 pack SC/PC Multi- mode 50µm, 900µm, Part No. SP-12SCMM50; 12 pack ST/PC Multi- mode 50µm, 900µm, Part No. SP-12STMM50;	Includes all industry fiber colors; Typical insertion loss .4dB;

Item	Manufacturer	Model/Part Number	Comments
			 \$60 each SC; \$70 each ST;
2.	Owner Preapproved Equal		
O. Acceptable Multi-Mode Fiber-Optic Cable Terminations MANUFACTURERS			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	SC - UniCam® ST - UniCam® 	UniCam® Multimode Connector for fiber with composite ferrule; \$20 each;
2.	LEVITON www.leviton.com	SC - Thread-Lock™ ST - Thread-Lock™ 	SC Housing & Boot ST Metal Housing & Boot; \$20 each;
P. Single-Mode Fiber-Optic Patch Cables			
Q. Acceptable Single-Mode Fiber-Optic Patch Cables MANUFACTURERS			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	Mode Conditioning Patch Cords, Part No. "Select"; - Select End "A" Connector (plant side): 05=LC, 17=FC, 50=ST® Compatible, 57=SC; - Select End "B" Connector (equipment side): 0504=LC MM/LC SM, 5772=SC MM/SC SM;	IEEE-802.3z Gigabit Ethernet (1000Base) Compliant; 

Item	Manufacturer	Model/Part Number	Comments
		- Select fiber type: B=50µm, K=62.5µm; - Select cable flame rating: 1=OFNR Riser, 8=OFNP Plenum; - Select length: use three digits, i.e. 10 meters =010; - Select length units: M=meters, F=feet;	
2.	Owner Preapproved Equal		
R. Multi-Mode Fiber-Optic Patch Cables			
S. Acceptable Multi-Mode Fiber-Optic Patch Cables MANUFACTURERS			
1.	CORNING CABLE SYSTEMS www.corningcablesystems.com	Mode Conditioning Patch Cords, Part No. "Select"; - Select End "A" Connector (plant side): 05=LC, 17=FC, 50=ST® Compatible, 57=SC; - Select End "B" Connector (equipment side): 0504=LC MM/LC SM, 5772=SC MM/SC SM; - Select fiber type: B=50µm, K=62.5µm; - Select cable flame rating: 1=OFNR Riser, 8=OFNP Plenum; - Select length: use three digits, i.e. 10 meters =010; - Select length units: M=meters, F=feet;	IEEE-802.3z Gigabit Ethernet (1000Base) Compliant; 

Item	Manufacturer	Model/Part Number	Comments
2.	Owner Preapproved Equal		
T. Acceptable Fiber-Optic Cable Fusion Terminations Other Materials MANUFACTURERS			
1.	FIBER INSTRUMENT SALES, INC. www.fiberinstrumentsales.com	Clear 2.36-inch (60mm) x 0.12-inch (3mm) (after shrink) Fusion Protection Sleeves - 50 pack, Part No. F1-1002C-50;	 \$20 each;
2.	FIBER INSTRUMENT SALES, INC. www.fiberinstrumentsales.com	Cable Tie Wraps - 4-inch (101.6mm) x 1/8-inch (3.17mm) 100-pack, Part No. T18S; 7-inch (177.8mm) x 1/8-inch (3.17mm) 100-pack, Part No. T50S;	 \$4 each;  \$5 each;
3.	Owner Preapproved Equal		

2.05 COPPER PROFIBUS® DP™ CABLE AND ACCESSORIES

- A. The requirements for copper PROFIBUS® DP™ Cable and accessories shall be as specified in Section 16120 - Wires And Cables – 600-Volt And Less;

2.06 COPPER ETHERNET CABLE AND ACCESSORIES

- A. The requirements for copper Ethernet Cable and accessories shall be as specified in Section 16120 - Wires And Cables – 600-Volt And Less;

2.10. RECOMMENDED UL508A CONTROL PANEL SHOPS

- A. The following shops have built and delivered acceptable control panels for the Owner;

1.	REVERE CONTROL SYSTEMS, INC.	Lakeland, FL	Attn: Roger Whitson

Item	Manufacturer	Model/Part Number	Comments
	www.reverecontrol.com	(863) 226-0219	(205) 824-1205 ext 3137 rwhitson@reverecontrol.com
2.	CURRY CONTROLS CO., INC. www.currycontrols.com	Lakeland, FL (863) 646-5781	Attn: Scott Cyphert (863) 646-5781 swc@currycontrols.com
3.	UNITRON CONTROLS (aka BARNEYS PUMPS) Barneypumps.com	Lakeland, FL (863) 665-8500	Attn: Robbie Pearce (863) 899-5770 pearcer@barneypumps.com
4.	Owner Preapproved Equal		
2.20. PRE-APPROVED ELECTRONIC BOARD REPAIR SHOPS			
A. The following shops have repaired electronic boards for the Owner;			
1.	ELECTRICAL SOUTH, INC. www.elsouth.com	Greensboro, NC (800) 950-9550	Attn: Manny Kourounis 12-month Warranty
2.	INDUSTRIAL REPAIR SERVICE www.boardrepairs.net	Cumming, GA (800) 950-2349	Attn: Bob Cate or Sandy Mitro Note: 18-month Warranty when part is installed;
3.	STERLING SERVICES www.sterlingservices.com	Matthews, NC (800) 280-4602	Attn:
4.	Owner Preapproved Equal		

PART 3 – EXECUTION

3.01 INSTALLATION

- A. To assist the ISS in determining the Scope of Work, a series of Loop Diagrams and Details are provided. Unless specifically stated otherwise, the ISS shall be responsible for providing all instrumentation, control equipment and auxiliary devices necessary to perform the functions specified herein and as shown and described on these diagrams. Any auxiliary devices such as lightning/surge protectors, relays, timers, signal isolators, signal boosters, etc. which are necessary for complete operation of the System, or to perform the functions specified shall be included, whether or not they are specifically shown or tabulated on the Loop Diagrams.
- B. The intent of the Loop Diagrams is to describe in as much detail as possible, the hardware, software and functional requirements of a process measurement and control system. They are not intended to convey requirements for conduit and wiring between panels or system components. This information is included in appropriate Electrical Specifications and Contract Drawings.
- C. Instrumentation and accessory equipment shall be installed in accordance with the Manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices shown on the Contract Drawings are approximate only. Exact locations shall be as approved by the Engineer and Owner during construction. Obtain in the field, all information relevant to the placing of process control work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.
- D. The instrumentation loop diagrams indicate the intent of the interconnection between the individual instruments. Any exceptions should be noted. Two complete sets of approved shop drawings shall be kept at the job site during all on site construction. Both sets shall be identically marked up to reflect any modifications made during field installation or start up. All markings shall be verified and initialed by the Engineer or his designated representative.
- E. Following completion of installation and the operational readiness test, one set of the marked up drawings shall be provided to the Engineer, the other retained by the ISS for incorporation of the mark ups into final as built documentation. Record drawings shall be as called out in Section 01050 of these Specifications.
- F. The instrumentation installation details on the Contract Drawings indicate the designed installation for the instruments specified. Where specific installation details are not specified or shown on the Contract Drawings, the API 550 shall be followed as applicable;

- G. All work shall be executed in full accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances and regulations, the ISS shall bear full responsibility for such violations and assume all costs arising there from.
- H. All equipment used in areas designated as hazardous shall be designed for the Class, Group, and Division as required on the Electrical Drawings for the locations. All work shall be in strict accordance with codes and local rulings, should any work be performed contrary to said rulings, ordinances and regulations, the ISS shall bear full responsibility for such violations and assume all costs arising there from.
- I. Unless specifically shown in the Contract Drawings, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands as detailed on the installation detail drawings. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, valve manifolds for calibration, testing, and blow down service shall also be provided. For slurries, chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.
- J. All piping to and from field instrumentation shall be provided with necessary unions, test tees, couplings, adaptors, and shut off valves;
- K. Field instruments requiring power supplies shall be provided with local electrical disconnects and fuses as required;
- L. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed in a workmanlike manner and not interfere with any other equipment.
- M. The ISS shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the ISS shall be required to ship his material in sections sized to permit passing through restricted areas in the building. The ISS shall also investigate, and make any field modifications to the allocated space for each cabinet, enclosure and panel to assure proper space and access (front, rear, side).
- N. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded as directed by the Manufacturer of the instrumentation equipment but in no case shall more than one ground point be employed for each shield.
- O. Lifting rings from cabinets/assemblies shall be removed and plugs shall be provided for the holes of the same color as the cabinet.
- P. The ISS shall coordinate the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the Engineer's approval. He shall be responsible to insure that all field wiring for power and signal circuits are correctly done in accordance with best industry practice and provide for all necessary system grounding to insure a satisfactory functioning installation. The ISS hereunder shall schedule and coordinate his work under this section with that of the electrical work specified under applicable Sections of Division 16.

3.02 FIBER OPTIC CABLE INSTALLATION

A. The ISS and the Contractor shall:

1. Provide all material, equipment and labor to install and test the fiber optic cables as indicated and as specified;
2. Installation shall be in accordance with the NEC® Article 770 and 800, ANSI/TIA/EIA-568-B and 569-B and the Manufacturer's recommendations;
3. The fiber optic cable Manufacturer shall approve installation tools, materials and methods;
4. Measure the attenuation of the fiber optic cable prior to installation and determine the average attenuation per foot;
5. Pull cables prior to attachment of connectors;
6. Fiber optic cables shall be continuous from component to component as shown on the Contract Drawings. Intermediate fiber splices shall not be allowed;
7. Continuously measure the pull tension during installation and do not exceed the manufacturer's stated maximum tension;
8. All cable shall be installed in conduit;
9. Inspect raceway prior to pulling cables. Notify the Owner of any conditions that would prevent installation of the specified cables, before proceeding with the installation. Rod and swab out ducts prior to installing cables;
10. Install non-breakout cables in conduit systems inside buildings and structures;
11. Pull cables by directly pulling only on the strength member. Contractor shall note from the distance markers on the cable the exact length of each installed run to provide on as-built Drawings;
12. Lubricate cables with lubricants specially formulated for fiber optic cable jackets during installation. Do not exceed cable Manufacturer's specifications for tensile strength and bending radius. Pulleys used to aid in the installation of the fiber optic cable must be sized according to the minimum-bending radius. The pulling tension of all fiber cables during installation shall be recorded using a strip recorder. The printout of the strip recorder shall be submitted to the Owner;
13. Do not make splices in cable unless approved by the Owner. Splices shall be made in designated enclosures above ground only. Provide adequate put up lengths on cable reels to make termination to termination runs without splices. Where splices are unavoidable, subject to the approval of the Engineer, provide

fusion splices with attenuation losses of 0.3-dB or less. Make splices watertight and provide mechanical protection equal to the cable jacket, or better;

14. Provide breakout kits, signal transceivers, power supplies, patch panels, pigtails and jumpers as required and as indicated to install a complete data highway communications network. Patch panels and splice enclosures shall be wall mounted;
 15. Support cables in riser conduits at intervals as required by NEC®;
 16. Following installation and termination of individual fibers measure the attenuation of each run and compare the attenuation per foot readings with those taken prior to installation. Replace any runs whose attenuation per foot reading is more than 10% higher than the pre-installation value;
 17. Within manholes, protect cable by providing flexible, corrugated, polyethylene slit duct. Connect slit duct-to-duct bank by using hose clamps. Support duct at ten (10) foot intervals;
- B. Identification: Label each termination point. Tag each cable in junction boxes, manholes and hand holes. Provide permanent nylon/plastic tie wrap type tags with waterproof markings. Label each cable, buffer tube and fiber with permanent waterproof typewritten tags.
- C. Each individual fiber termination shall be performed using fusion splicing technology. No exceptions.

3.03 ADJUSTING AND CLEANING

- A. The process instrumentation and controls shall be adjusted accordingly, per Manufacturer's recommendations.
- B. Clean exposed surfaces using Manufacturer recommended materials and methods.
- C. Vacuum all interior spaces.

3.04 GENERAL TESTING

- A. The ISS shall test all equipment, hardware and software, to be furnished under this Contract.
 1. All tests shall be conducted in accordance with prior Engineer approved procedures, forms, and checklist. Each specific test to be performed shall be described and a space provided after it for sign off by the appropriate party after its satisfactory completion.
 2. Copies of these sign off test procedures, forms, and checklists will constitute the required test documentation.

3. Provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, ISS shall provide suitable means of simulation. Define these simulations techniques in the test procedures.
4. The ISS shall coordinate all of his testing with the Engineer, Contractor, all affected Subcontractors, and the Owner;
5. The Engineer reserves the right to test or retest all specified functions whether or not explicitly stated in the prior approved test procedures.
6. The Engineer's decision shall be final regarding the acceptability and completeness of all testing;

3.05 OPERATIONAL TESTING

- A. General: Prior to startup, the entire system shall be certified (inspected, tested and documented) that it is READY for operation;
- B. Network Test: Each device in the control system network shall successfully ping and be pinged from other network devices;
- C. Loop/Component Inspections and Tests: The entire system shall be checked for proper installation, calibrated, and adjusted on a loop by loop and component by component basis to ensure that it is in conformance with related submittals and these Specifications.
 1. The Loop/Component Inspections and Tests shall be implemented using Engineer approved forms and check lists. Each loop shall have a Loop Status Report to organize and track its inspection, adjustment, and calibration. These reports shall include the following information and check off items with spaces for sign off by the ISS:
 - a. Project Name;
 - b. Loop Number;
 - c. Tag Number for each component;
 - d. Check offs/sign offs for each component - Tag/identification; Installation; Termination wiring; Termination tubing; Calibration/adjustment;
 - e. Check offs/sign offs for the loop - Panel interface terminations; I/O interface terminations; I/O signal operation; Inputs/outputs operational: received/sent, processed, adjusted; Total loop operation
 - f. Space for comments;

2. Each active Analog Subsystem element and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry, and a space for sign off by the ISS:
 - a. Project Name;
 - b. Loop Number;
 - c. Component Tag Number of I/O Module Number;
 - d. Component Code Number Analog System;
 - e. Manufacturer (for Analog system element);
 - f. Model Number/Serial Number (for Analog system);
 - g. Summary of Functional Requirements; For example:
 - For Indicators and Recorders: Scale and chart ranges;
 - For Transmitters/Converters: Scale and chart ranges;
 - For Computing Elements: Function
 - For Controllers: Action (direct/reverse) control Modes (PID);
 - For Switching Elements: Unit range, differential (Fixed/Adjustable), reset (Auto/Manual);
 - For I/O Modules: Input or output;
 - h. Calibrations. For example:
 - For Analog Devices: Required and actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling;
 - For Discrete Devices: Required and actual trip points and reset points.
 - For Controllers: Mode settings (PID);
 - For I/O Modules: Required and actual inputs or outputs for 0, 10, 50, and 100 percent of span, rising and falling;
 - i. Space for comments;
 - j. Space for sign off by the ISS;
 3. The ISS shall maintain the Loop Status Reports and Components Calibration sheets at the job site and make them available to the Engineer/Owner at any time;
- D. These inspections and tests do not require witnessing. However, the Engineer will review and initial all Loop Status Sheets and Component Calibration Sheets and spot check their entries periodically and upon completion of the Operational Test. Any deficiencies found shall be corrected.

- E. Upon successful completion the Operational Test and subsequent review and approval of complete system final documentation, the System shall be considered complete.

3.06 FIBER OPTIC CABLE TESTING

- A. ISS and Contractor shall conduct a physical checkout of the fiber optic network;
 - 1. Physical checkout shall be performed prior to functional testing;
 - 2. Verify that the fiber optic cable reels have been off-loaded from the truck carefully and not damaged;
 - 3. Submit to the Engineer all test data provided by the fiber optic cable Manufacturer;
 - 4. Verify that the optical fibers of the cable assembly are the type and quantity required;
 - 5. Verify that cable construction is the type specified;
 - 6. Verify that fiber optic patch panels have been installed plumb and level at locations indicated;
 - 7. Verify that optical fiber connections or terminations within patch panels and splice closures are in accordance with cable Manufacturer's recommendations and instructions;
- B. Make the following site tests before removing cable from cable reels:
 - 1. Determine attenuation losses of each fiber from end to end. Use an optical time domain reflectometer (OTDR) to capture and record. Provide a printout of the captured data to the Engineer;
 - 2. Submit to the Engineer all test data and models of test equipment, calibration standards and tests;
- C. Make the following field tests after fiber cable and connector installation:
 - 1. All fiber optic cables shall be tested for performance and loss after cable installation and connector termination to certify that at least a 3dB power safety margin is obtained between all transmitters and receivers. Test data for 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. The following tests shall be performed as a minimum but not limited to:
 - a. Visually, inspect terminal connectors for out of round condition and surface defects such as micro chips and cracks using a 200X (minimum) inspection microscope;

- b. Check optical continuity of each fiber from terminal to terminal. Use test equipment as specified herein and provides electronic report certifying each fiber in every cable;
 - c. Verify the calculated attenuation power losses of each fiber from both transmit and receive terminals of each data communications loop (both directions). The light source and operating wavelength of the test equipment shall be representative of the actual operating equipment. Use an OTDR;
 - d. Submit to the Engineer all test data and models of test equipment, calibration standard and tests;
- D. Owner may observe testing. Inform Owner of testing schedules at least one-week prior to start of testing.

3.07 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service;
- B. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
- C. Verify that all process instrumentation and controls are installed and connected according to the Contract Documents.
- D. Verify that electrical and control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
- E. Verify that wiring installation complies with requirements in Division 16 Sections.
- F. Complete installation and startup checks according to Manufacturer's written instructions.

3.08 WARRANTY

- A. Provide equipment warranty per Section 01740 and herein.
- B. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

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SECTION 13315

FIELD INSTRUMENTATION

PART 1 – GENERAL

1.01 SCOPE

- A. Furnish all labor, materials, equipment and incidentals required, to install, complete and ready for operation, the devices and/or panels depicted on the Contract Drawings and on the Instrumentation Details provided.
- B. Related Work Specified Elsewhere
 - 1. Division 1 – General Requirements;
 - 2. Division 13 – Special Construction;
 - a. Section 13300 – Process Instrumentation and Controls;
 - b. Section 13310 – Programmable Logic Controller (PLC) and Digital Equipment;
 - 3. Division 16 – Electrical;
- C. Provide complete lightning and surge protection per Section 16709 – Protectors and Surge Protection Devices (SPDs) on all field instrumentation for power, communication and signal.
- D. The Contractor shall be responsible for coordinating all instrumentation sensor and transmitter electronics mounting, power, signal and communications requirements and shall furnish dimensional and elevation drawings to ensure a proper and satisfactory installation.

1.02 REFERENCES

- A. Refer to Section 13300 - Process Instrumentation and Controls for specifics.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. At a minimum, submit Manufacturer's catalog data and descriptive literature for each device being supplied. Show materials of construction by ASTM reference and grade. Identify each device by tag number to which the catalog and descriptive literature pertain.
- E. Refer to Section 13300 - Process Instrumentation and Controls for additional information.
- F. The Field Instrumentation Manufacturer shall be ISO certified.
- G. UL Listing Requirements -
 - 1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
 - 2. The Field Instrumentation shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Enter the code into Category Code search box and click Search.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver Field Instrumentation product(s) in factory labeled packages.
- B. Handling and shipment of the equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in controller and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.05 SPARE PARTS

- A. One year's supply of items recommended by the Manufacturer of the equipment for each component in this Specification. Contractor shall provide a statement from the Manufacturer of each instrument, either standard published product literature or a written statement on their letterhead, which states the recommended spare parts for one year's operation for each instrument provided.
- B. Provide other spare parts as indicated on the individual device specifications.

- C. The spares listed above shall be packed and labeled in a manner suitable for long term storage and shall be adequately protected against corrosion, humidity and temperature.
- D. Contractor shall provide other spare parts as indicated on the individual device spec.

PART 2 – PRODUCTS

2.01 FLOW

- A. A. Fluid flow is defined as the amount of fluid that travels past a given location. The following equations describes the flow of a fluid in a pipe:

$Q = A \times v$; Q is the volumetric flow rate (per time), A is the cross-sectional area of the pipe, and v is the average fluid velocity in the pipe. Putting this equation into action, the flow of a fluid traveling at an average velocity of a 1 meter per second through a pipe with a 1 square meter cross-sectional area is 1 cubic meter per second;

$W = \rho \times Q$; where W is mass flow rate (per time) and ρ is the fluid density. The flow rate will be 1 kilogram per second when 1 cubic meter per second of a fluid with a density of 1 kilogram per cubic meter is flowing;

2.02 FLOW (CONTINUOUS) USING VARIABLE AREA (DIRECT READING) (FI)

- A. The variable area (VA) meter, also commonly called a rotameter, consists of a tapered tube, typically made of glass, with a float inside that is pushed up by fluid flow and pulled down by gravity. As flow rate increases, greater viscous and pressure forces on the float cause it to rise until it becomes stationary at a location in the tube that is wide enough for the forces to balance. Floats are made in many different shapes, with spheres and spherical ellipses being the most common. Some are designed to spin visibly in the fluid stream to aid the user in determining whether the float is stuck or not. Rotameters are available for a wide range of liquids but are most commonly used with water or air. They can be made to reliably measure flow down to 1% accuracy.

Other manufacturers include:

KING (www.kinginstrumentco.com), BROOKS (www.brooksinstrument.com), ABB aka FISCHER & PORTER (www.abb.com) and SIEMENS USF (U.S. FILTER) Wallace & Tiernan (www.water.siemens.com);

B. Acceptable Variable Area Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	DWYER® INSTRUMENTS www.dwyer-inst.com	In-line Flow Alarms Series HFO Stainless Steel; 	Direct reading; install in any position; 360° rotatable guard/scale; easy-to-read linear scale; no flow straighteners or special piping required; relatively insensitive to shock and vibration; temperature up to 240 °F (115 °C); accuracy ± 2% full scale; repeatability ±1%; 1-Year Warranty; \$500 each;
2.	HEDLAND® www.hedland.com	Flo-tech® EZ-VIEW® Flow Meters with Stainless Steel Fittings ½-inch to 2-inch / 4 to 100 GPM; 	\$500 each;

2.03 LEVEL (POINT)

A. Point level measurement sensors are used to mark a single discrete height – a preset level condition. Generally, this type of sensor functions as an alarm, signaling a high or low condition, or as a marker.

B. Level (Point) Using Wet Well Float Sensor (Mercury-Free) (LSL, LSLL, LSH, LSHH)

1. Float level switches shall consist of a mechanical switch, a moving float, and a connecting cable which is anchored;
2. As the level rises and falls the float rights itself or inverts causing switching actions;
3. The cable anchoring point shall be protected by strain relief;
4. The hermetically sealed switches shall be SPDT with a minimum rating of 10 A at 120 VAC;
5. Include all necessary accessories, supports and weights, for complete installation as specified and as shown on the Contract Drawings.
6. For use in wet wells (High-High, High, Low, Low-Low Alarms);
7. ALL Mercury-free;
8. Use stainless steel mounting clamps;
9. Requires intrinsically safe relay;

C. Acceptable Level Using Wet Well Float Sensor (Mercury-Free) Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	ANCHOR SCIENTIFIC INC. www.anchorscientific.com	ECO-FLOAT; 	The Eco-Float is a mercury-free float switch for controlling liquid levels in a variety of applications. A snap-action switch is activated by a steel ball rolling back and forth within a switching tube in plastic-float housing. There is a minimum differential between "on" and "off" of approximately 3.5 inches. Greater differentials can be achieved when the pipe mounted or externally weighted mounting styles are used.
2.	SIEMENS WATER TECHNOLOGIES www.water.siemens.com	US FILTER Model 9G-EF; 	Three-year warranty;

2.04 PRESSURE

A. Pressure results from molecules in either a gas or liquid exerting a force by impacting over a defined area. The relationship is given by: Pressure (p) = Force (F)/Area (A). Commonly used engineering units for pressure are pounds per square inch (psi) or atmospheres, describe this relationship.

1. Gauge Pressure - Indicates pressure from a single source and uses ambient pressure as zero.
2. Absolute Pressure - The pressure measured above a perfect vacuum. It's the pressure indicated by an ordinary gauge added to the atmospheric pressure.
3. Differential Pressure - The difference between two independent, but related pressures.
4. Compound Pressure Gauges - Indicate pressures above & below ambient pressure or positive & negative pressure.
5. Duplex Gauges - Utilizes two independent sensing elements each connected to different but related pressure sources.

B. ASME B40.1-1998 recommends that normal operating pressure be confined to 25%-75% of the scale. If pulsation is present in the process, maximum operating gauge pressure should not exceed 50% of the full-scale range.

- C. Environmental considerations include ambient temperature, air-borne particulate, condensation, humidity, water and chemicals, all of which can affect gauge performance.
- D. For a mechanical pressure gauge, accuracy is defined as a percentage of the full-scale range. While requirements differ, the following are general guidelines:
 - 1. Test Gauges and Standards: 0.25% through 0.10% full scale;
 - 2. Critical Processes: 0.5% full scale;
 - 3. General Industrial Processes: 1.0% Less Critical Commercial Uses: 2.0%;
- E. Refer to ASME B40.1-1998 or the DIN specifications for more information on accuracy.
- F. Pressure gauge dial sizes range from 1-½-inch to 16-inch diameters. Generally, readability requirements, space limitations and required gauge accuracy determine dial size.
- G. Gauges are available with a variety of connections including NPT, DIN, JIS, BSP & SAE. Process pressure gauges with 4-½-inch dial sizes or larger are most often supplied with a ½-inch NPT connection to best support the gauge.
- H. Consider the following mounting options when selecting a pressure gauge:
 - 1. Direct stem mount lower connect;
 - 2. Remote wall/surface mount lower connect;
 - 3. Panel surface mount back connect;
 - 4. Panel hole U-clamp flush mount back connect;
 - 5. Panel hole front flange flush mount back connect;

2.05 PRESSURE (CONTINUOUS) USING GAUGE WITH DISPLAY (PIT)

- A. Analog pressure transmitters for gauge pressure suitable for liquid, gas and vapor service;
 - 1. Unit Type: Microprocessor based, intelligent type, diaphragm actuated.
 - 2. Functional/Performance:
 - a. 0...9999 psi g span;
 - b. Accuracy - 0.1% of span (linear output);

- c. Stability - Combined temperature effects shall be less than 0.2% of maximum span per 50 °F temperature change; Effect on accuracy due to static pressure changes shall be negligible;
 - d. Power Requirements – 24-VDC, 60-Hertz;
 - e. Output - PROFIBUS® DP™ serial connection transmitting measured pressure or differential pressure-based flow rate, and all available diagnostic data and 4-20mA;
 - f. RFI Protection - 0.1% error between 27 and 500 MHz at 30 v/m field intensity;
 - g. Drift - 0.10% per six months for 4-20mA output;
 - h. Sensor Technology Digital;
 - i. Over-range Protection Provide positive over-range protection;
3. Physical:
- a. Electrical Classification - Intrinsically safe for Class I and Class II, Division 1 locations;
 - b. Enclosure - NEMA 4X, housing stainless steel precision casting;
 - c. Sensor Diaphragm Material – Stainless steel;
 - d. Gaskets - Teflon.
 - e. Sensor Fill Fluid - inert liquid measuring cell filling; grease-free measuring cell cleaning; suitable for process fluid being measured; when used for chemical metering service, sensor fill fluid shall be rated specifically for the chemical being measured;
 - f. stainless steel female thread ½-inch NPT process connection;
 - g. screwed gland ½-inch NPT electrical connection-cable entry;
 - h. 4-20mA Outputs ONLY, No field bus supported;
4. Options/Accessories Required:
- a. Provide span and zero adjustment at each transmitter;
 - b. Provide hand held programmer(s);

- c. For each transmitter provide a valve manifold with stainless steel mounting bracket as required. The manifold shall be Type 316 stainless steel and provide the following modes of operation:

- 1) Normal Mode
- 2) Zeroing Mode
- 3) Isolation Mode
- 4) Calibration Mode
- 5) Blowdown Mode

B. Acceptable Pressure (Continuous) Using Gauge With Display Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EMERSON® PROCESS MEASUREMENT www.emersonprocess.com	ROSEMOUNT® ANALYTICAL 3051 Series with ROSEMOUNT 306 Inline Manifold Double Shut-off Valves, Sleeve-Collar, Stainless Steel, ½-inch NPT;	3-Year Warranty;  \$1,600 each;
2.	SIEMENS INDUSTRY www.siemens.com	SITRANS P DSIII Series with Part No. 7MF9011-4FA Double Shut-off Valves, Sleeve-Collar, Stainless Steel, ½-inch NPT;	5-Year "Powered" Warranty;  \$1,600 each;

2.06 PRESSURE (CONTINUOUS) GAUGE INDICATION ONLY (PI)

- A. Complies with ASME B40.100 Pressure Gauges and Gauge Attachments, ASME B40.1, Pressure Indicating Dial Type – Elastic Element Gauges, Grade 1A ($\pm 1\%$ of span);
- B. Pressure Range: 0 – 30-psi (0 – 60-psi) gauge;
- C. Solid or open front with side or rear blowout relief;
- D. Pressure tight;
- E. 270-degree arc with adjustable pointer;

- F. Stem mounted;
- G. Size of gauge shall be 4 ½-inches, unless otherwise indicated on the Contract Drawings;
- H. Stem or connection size shall be ½-inch;
- I. Materials of Construction:
 - 1. Case – AISI 316 Stainless Steel;
 - 2. Bourbon tube – AISI 316 Stainless Steel;
 - 3. Windows – Shatterproof glass;
 - 4. Ring – AISI 316 Stainless Steel;
 - 5. Stem – AISI 316 Stainless Steel;
 - 6. Dial face – Aluminum with clear baked-on acrylic coating per ASTM B209, 6061-T6;
- J. Contractor shall provide one complete gauge tool kit for each four (4) pressure gauges supplied, containing the following at a minimum:
 - 1. hand jack set;
 - 2. screwdriver;
 - 3. five reamers (minimum);
 - 4. two pin vise holders;
 - 5. wiggler;
 - 6. tweezers;
 - 7. carrying case;
- K. 5-Year Limited Warranty;
- L. All pressure gauges shall be furnished with an isolation spool and isolation ball valve. Body, stem and all other parts of the ball valve shall be manufactured of Type 316 Stainless Steel. Valve packing shall be high-density TFE. Valve connections shall be ½ - inch female NPT threaded connections. SWAGELOK® COMPANY Series 45 On-Off (2-Way) Valves or PARKER-HANNIFIN CORPORATION Two-Way B Series Ball Valves;

M. Acceptable Pressure (Continuous) Gauge Indication Only Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	DRESSER INSTRUMENTS www.ashcroft.com	ASHCROFT® Type 1009 Duralife® Pressure Gauges, ASME B 40.1 Grade 1A ($\pm 1\%$ of span);	
2.	WIKA INSTRUMENTS www.wika.com	Bourbon Tube Pressure Gauges, Stainless Steel Series: Type 232.50 - Dry Case; Type 233.50 - Liquid-filled Case;	

2.07 PRESSURE ISOLATION SPOOL/RING

- A. Obtaining accurate pressure readings on slurry lines is difficult because slurries, abrasives and solids clog pressure elements;
- B. Isolation rings shall be designed to permit pressure measurement on slurries and other hard-to-handle fluids without compromising gauge, switch or transmitter function. Isolation ring shall consist of a metal ring with an elastomer inner tube filled with silicone instrument oil. Center section of isolator ring shall be carbon steel. End plates shall be Acetal Homo Polymer (316 Stainless Steel, KYNAR, or TEFLON) and elastomeric sleeve shall be Nitrile (or EPDM, VITON);
- C. Sensors shall either be -
 1. Fit inside the bolt circle of 150# ANSI flanges (or shall be provided with appropriate spacers for 300# or 600# flanges); Face to face length of the sensor shall conform to specification MSS-SP67. Sensor shall be flow through design with flexible rubber sleeve around full circumference. The center section shall have a cavity behind the rubber sleeve filled with silicone fluid to transfer pressure to the gauge; or
 2. Full flange style with through bolt holes. Face to face length of the sensor shall conform to specification MSS-SP67. Sensor shall be flow through design with flexible rubber sleeve around full circumference. The center section shall have a cavity behind the rubber sleeve filled with silicone fluid to transfer pressure to the gauge;
- D. All pressure instruments attached to the sensor shall be rigidly supported by a post at least 0.875-inches diameter welded to the isolator. On sensor rings with more than one instrument, all connections shall be 1/2-inch NPT as a minimum. 1/4-inch NPT fittings are

not acceptable. The sensor ring shall not have a fill plug that can be inadvertently removed with the resultant loss of fill fluid.

E. The sensor shall be vacuum filled and permanently sealed at the factory with a modular seal consisting of a rubber membrane and needle fitting to allow removal and replacement of pressure instruments without compromising the vacuum fill. The needle fitting shall have both ¼-inch NPT (F) thread and ½-inch NPT (M) threads. The pressure isolator shall be capable of operating under pressure with all instruments removed with no loss of fill fluid, without isolating valves. Pressure instruments shall be attached to the isolator with a hand tightened lock ring. It shall be possible to remove, rotate or attach pressure instruments to the isolator without requiring the use of any tools. The pressure sensor shall be permanently filled with high viscosity silicone instrument oil to damp out surges or pressure spikes without a separate snubber.

F. Benefits of an Isolation Spool/Ring -

1. Gauges can be removed or replaced without interrupting process;
2. Gauges can be replaced without vacuum filling;
3. No tools required to change pressure instrument (turn the lock ring);
4. No Snubber required (needle functions as built-in Snubber);
5. Improved safety (process liquid cannot escape if gauge is removed);
6. High accuracy (because air can never get into the system);
7. No isolation valve required;
8. Gauges can be rotated by hand to face any direction;
9. Isolation rings and gauges can be stocked separately (combine as needed on the spot);

G. Acceptable Pressure (Continuous) Isolation Spool Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	ONYX VALVE www.onyxvalve.com	PSW or PSR Pressure Isolator Ring; 	Center Section & End Plates - 316 Stainless Steel; Elastomer - Nitrile (Buna-N); Silicone Fluid Fill; Vacuum to 1000 psi Range;

Item	Manufacturer	Model/Part Number	Comments
2.	OPW® ENGINEERED SYSTEMS www.opw-es.com	Iso-Ring® Isolation Ring; 	OPW purchased the Ronninger-Petter product line in 1996;
3.	NO EQUAL		

2.08 PRESSURE (CONTINUOUS) SWITCH WITH DISPLAY (PS, PAL, PAH, PIT)

- A. The electronic pressure switch/transmitter shall provide both adjustable switches and 4-20mA transmission of the pressure;
1. UL Listed;
 2. Watertight Enclosure: Type 4X/IP66 certified epoxy-coated aluminum construction;
 3. Faceplate: UV-resistant pressure sensitive keypad and display overlay;
 4. Conduit: ½-inch NPT female stainless steel fitting;
 5. Electronic, Programmable with Local Display;
- B. Acceptable Pressure (Continuous) Switch With Display Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	UNITED ELECTRIC CONTROLS www.ueonline.com	One Series Smart Transmitter-Switch, Part No. 1XTXSW SW1&2 0-280VAC/VDC @ 0.3A; Use appropriate sensor (P06-P20) for the application. Typical P15;	Loop-powered 24VDC; 3-Year Warranty;
2.	Owner Preapproved Equal		

2.09 INSTRUMENT TUBING & FITTINGS (REF. 13300-2.03.)

- A. All instrument tubing shall be fully annealed ASTM A269 Seamless Type 316 stainless steel free of O.D. scratches having the following dimensional characteristics as required to fit the specific installation:
1. ¼-inch to ½-inch O.D. x 0.035-inch wall thickness;
 2. 5/8-inch to 1-inch O.D. x 0.049-inch wall thickness;

3. 1-inch O.D. x 0.065-inch wall thickness;
4. 1-¼-inch O.D. x 0.065-inch wall thickness;
5. 1-½-inch O.D. x 0.083-inch wall thickness;
6. 2-inch O.D. x 0.095-inch wall thickness;
7. All instrument process connections shall be ½-inch O.D. Type 316 stainless steel tubing;
8. All instrument air header takeoffs and branch connections less than 2-inch shall be Type 316 stainless steel;
9. All instrument fittings, filters and valves shall be Type 316 stainless steel;
10. All instrument shut off valves and associated fittings shall be supplied in accordance with the specifications and instrument installation details;
11. All tube track shall be installed as per Manufacturer's installation instructions and supported by stainless steel struts;

B. Acceptable Instrument Tubing & Fittings Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	HY-LOK USA www.hylokusa.com	Type 316 Stainless Steel Tube, Fittings, Valves, & Other System Components;	
2.	SWAGELOK® COMPANY www.swagelok.com	Type 316 Stainless Steel Tube, Fittings, Valves, & Other System Components;	
3.	PARKER-HANNIFIN CORPORATION www.parker.com	Type 316 Stainless Steel Tube, Fittings, Valves, & Other System Components;	

C. Acceptable Instrument ¼ or ½-inch NPT Stainless Steel Ball Valve Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	CONBRACO INDUSTRIES www.apollovalves.com	Apollo® Valves Series 76F - Threaded, 2-Piece, Full Port, Stainless Steel Ball Valve;	
2.	INLINE INDUSTRIES www.ballvalve.com	201F Series;	
3.	Owner Preapproved Equal		

2.10 VIBRATION (SEISMIC) SWITCHES (VAH)

A. DPDT Relay output;

B. Acceptable Vibration (Seismic) Switch Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	INVENSYS ROBERTSHAW® www.robertshawindustrial.com	Model 375A/376A Vibraswitch® Malfunction Detectors;	
2.	METRIX INSTRUMENT CO. www.metrix1.com	Model 440;	

2.11 POSITION INDUCTIVE PROXIMITY SENSORS (ZS, ZSC, ZSO)

A. The most commonly-used proximity sensor is the inductive type, which generates an electromagnetic field to sense metal objects passing close to its face. This is usually the easiest sensing technology to apply in applications where a metal object to be detected is within an inch or two of the sensor face.

B. All applications within Wastewater have certain specific needs. The following features shall be provided unless Owner approval is provided in writing to provide an alternate:

1. UL Listed;
2. 0.315-inches (8mm) Standard Sensing Distance;

3. 2-wire cable;
4. NEMA 4X (IP68) Stainless Steel barrel;
5. LED status indicator visible 360° around the cylinder;
6. Withstands high electrical noise (up to 20 V/m);
7. Wide temperature range –13° to 158°F (–25° to 70°C)

C. Acceptable Position Inductive Proximity Sensor Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EATON CORPORATION www.eaton.com	CUTLER HAMMER® Part No. E57SAL18A2E;	E57 Premium+ Series 2-Wire DC N.O. Output, 18mm Short Barrel Sensor, 2-meter cable; 
2.	ROCKWELL AUTOMATION www.ab.com	ALLEN-BRADLEY® Part No. 871TM-B8N18-H2;	871TM 2-Wire DC N.O. Output Stainless Steel Face/18mm Threaded Short Stainless Steel Barrel, ToughLink™ Cable; 
3.	Owner Preapproved Equal		

2.12 POSITION LIMIT SWITCHES (ZS, ZSC, ZSO)

- A. A limit switch is an electro-mechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection. Limit switches are used in a variety of applications and environments because of their ruggedness, simple visible operation, ease of installation and reliability of operation.
- B. Rugged; UL Listed; NEMA Type 4 oil-tight construction; NEMA A600 AC Contact Rated; Single-Pole Double-Throw (SPDT) contacts; 10A Rated Thermal Current; 120VAC limit switches for positive indication;

C. Acceptable Position Limit Switch Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EATON CORPORATION www.eaton.com	CUTLER HAMMER® E50 Heavy-Duty Plug-In Limit Switches	
2.	ROCKWELL AUTOMATION www.ab.com	ALLEN-BRADLEY® Bulletin 802T Oil-tight Plug-in Heavy Duty Industrial Limit Switches;	
3.	SCHNEIDER ELECTRIC www.schneider-electric.us	SQUARE D® Heavy Duty Industrial Class 9007AW;	
4.	SIEMENS INDUSTRY www.siemens.com	3SE03 North American Heavy Duty Industrial (non-Safety) Class;	

2.13 INTRUSION SWITCHES (ZS, ZSC, ZSO)

A. Acceptable Intrusion Switch Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EATON CORPORATION www.eaton.com	CUTLER HAMMER® E47BLS05 Miniature Limit Switches;	
2.	ROCKWELL AUTOMATION www.ab.com	ALLEN-BRADLEY® Bulletin 802B Compact Limit Switches;	
3.	SCHNEIDER ELECTRIC www.schneider-electric.us	SQUARE D® 9007 MS/ML Limit Switches;	
4.	SIEMENS INDUSTRY www.siemens.com	3SE5 Class;	

2.14 COMBUSTIBLE GAS DETECTORS (%LEL)

- A. Detect and monitor combustible hydrocarbon gases in the lower explosive limit range, Alarm Outputs, 4-20mA;
- B. Acceptable Combustible Gas Detector Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	GENERAL MONITORS www.generalmonitors.com	Model IR4000M and Calibration Kit;	 Download a product manual Download a data sheet Ask us a question about this product
2.	SIERRA MONITOR CORP. www.sierramonitor.com	Model No. 5100-02-IT-SS and Calibration Kit;	
3.	DRAGER USA www.draeger.us	Polytron 5700, 334 d S Aluminum Body without relays, Part No. 4544220; Status Indicator for PIR 7000, Part No. 6811625; Splash Guard for PIR 7000, Part No. 6811911; and Calibration Kit;	 \$2,200 complete;

2.15 LIQUID ANALYSIS, CONTINUOUS PH

- A. pH is the unit of measure for the acidity of a solution in a process;
- B. Acceptable Liquid Analysis, Continuous pH Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	ABB www.abb.com	Model No. AX466 62001 Wall-mount Dual Analyzer with pH Sensor, Part No. AP303/21020001 with PROFIBUS® DP™ Communications;	C2 prefers ABB;  \$ each;
2.	CERLIC ENVIRONMENTAL CONTROLS www.cerlic.com	Model No. pHX with BB2 Control Box with PROFIBUS® DP™ Communications;	
3.	EMERSON® PROCESS MEASUREMENT www.emersonprocess.com	ROSEMOUNT® ANALYTICAL Model No. 1056 Intelligent Four-Wire Analyzer for pH with PROFIBUS® DP™ Communications;	 3-Year Warranty;

2.16 21/8 DIN UNIVERSAL PROCESS INDICATORS

A. Features;

1. 0-20-mA, 4-20-mA, 0-5 V, 1-5 V and ± 10 V Inputs;
2. NEMA 4X, IP65 Front;
3. Universal 85-265 VAC or 12/24 VDC Input Power;
4. Large Dual-Line 6-Digit Display;
5. Dual-Scale for Applications – Single Input
6. Isolated 24 VDC @ 200 mA Transmitter Power Supply
7. Math Functions
8. 2 or 4 Relays + Isolated 4-20 mA Output Options
9. External 4-Relay & Digital I/O Expansion Modules

10. RS-232, RS-422/485 Serial Communication Options

11. Modbus® RTU Communication Protocol Standard

B. Acceptable 1/8 DIN Universal Process Indicators Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	PRECISION DIGITAL CORPORATION www.predig.dicom	ProVu Dual-Line 6-Digit Process Meter (No Options Installed; Powered from 85-265-VAC), Part No. PD6000-6R0 Process Meter;	 \$300 each;
2.	RED LION® CONTROLS www.redlion.net	PAX® Model No. PAX2A – 1/8 DIN Analog Panel Meter, Part No. PAX2A000;	

2.17 . THERMOSTAT/SWITCH, HIGH TEMPERATURE (TSH)

A. NEMA 4X Enclosure; sealed SPDT 120VAC contacts; treated to resist corrosion, dust, dirt, and humidity; Heating Adjustment Range: 35 to 100 °F; Cooling or Ventilating Adjustment Range: 70 to 140 °F;

B. Acceptable Thermostat/Switch, High Temperature Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	PECO MANUFACTURING www.pecomanufacturing.com	Model No. TF115-001; 	40 to 110 °F Coil - Stainless steel with SPDT;
2.	HONEYWELL INTERNATIONAL INC. www.honeywell.com	Thermostat, Water Tight, Agricultural Temperature Controller, Part No. T631F1084;	
3.	Owner Preapproved Equal		

2.18 ALARM BEACONS

A. Features:

1. Supports outlet box, wall bracket or pipe mounting;
2. NEMA 4X Rated;
3. 120-VAC;
4. 3.5-inch (89-mm) Red LED Beacon;
5. Steady-on or up to 60 flashes per minute mode
6. -4° to 122°F (-20° to 50°C) Operating temperature;
7. UL Listed;

B. Acceptable Alarm Beacon Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EDWARDS SIGNALING & SECURITY SYSTEMS™ www.edwards-signals.com	Model No. 105XBRM Series XTRA-BRITE™ LED Adverse Location Visual Signal;	
2.	ROCKWELL AUTOMATION www.ab.com	ALLEN-BRADLEY® Bulletin 855BS Industrial Round Beacon;	
3.	Owner Preapproved Equal		

2.19 ELECTRONIC HORNS

A. Features:

1. Panel-mount or enclosed (application specific);
2. NEMA 4X Enclosure, suitable for outdoor use;;
3. Approx. 90-dB @ 10-feet;
4. 120-VAC;
5. UL Listed;

B. Acceptable Electronic Horn Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	EDWARDS SIGNALING & SECURITY SYSTEMS™ www.edwards-signals.com	For Panels: Model No. 870P AC Series or Model No. 871P DC Series AdaptaHorn® Panel Mount Vibrating Horn, NEMA Type 4X; For Standalone: Model No. 876 AC Series or Model No. 877 DC Series Adapter Horn® Weatherproof, NEMA Type 4X Enclosed;	Adjustable output: 78 to 101 dB; 
2.	ROCKWELL AUTOMATION www.ab.com	ALLEN-BRADLEY® Bulletin 855H General Purpose Electronic Horn; 	108dB(A) maximum; Suitable for humid, dirty, and corrosive environments (Surface mount version rated UL Type 4/4X/13, IP66; Semi-flush mount version rated UL Type 3R/13, IP54; UV- stable polycarbonate housing, ideal for outdoors);
3.	Owner Preapproved Equal		

2.20 INTRINSICALLY SAFE RELAYS FOR HAZARDOUS LOCATIONS

A. Acceptable Intrinsically Safe Relays For Hazardous Locations Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	GEMS™ SENSORS & CONTROLS www.gemssensors.com	SAFE-PAK® Relays;	
2.	PEPPERL+FUCHS www.pepperl-fuchs.us	K-System Isolated Barriers;	
3.	R. STAHL INC. www.rstahl.com	INTRINSPAK Series 9001;	

2.21 SIGNAL CONDITIONERS

A. Any system can come up against adverse dynamic conditions like: Lightning transients, Utility-line fault clearance transients, Sensor response characteristics, Differences of ground potential, Power supply regulation, Signal/noise ratio, white or black noise, Radio frequency interference (RFI), System reverberation, Thermal gradients, AC and DC actuator switching and Logic ambiguities. Signal Conditioners are used to resolve the above. Specific conditioners used by the Owner include:

1. TOTALIZER - Convert DC mA Signal to a Proportional Pulse Rate (mA Input, up to 10kHz Output);
2. MULTIPLIER - Analog Multipliers / Dividers - A X B, Any Analog In or Out;
3. ISOLATOR - DC to DC Converters - Optical Isolator, Any DC In or Out;
4. TRANSMITTER - DC to DC Converters - Optical Isolator, any AC Voltage Input, any Analog Out;
5. RAMP GENERATOR - Ramp time control module with ten turn dials;

B. Acceptable Signal Conditioners Manufacturers

Item	Manufacturer	Model/Part Number	Comments
1.	ACROMAG, INC. www.acromag.com	Model No. 800A/800T/800M Series;	
2.	AGM ELECTRONICS www.agmelectronics.com	Totalizer - Model No. 4011-10; Multiplier – Model No. 4008-4; Isolator – Model No. 4000-22; Transmitter – Model No. 4001-1; Generator – Model No. 4009-03;	

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The equipment shall be installed as shown on the Contract Drawings and in accordance with the Manufacturer's recommendations.
- B. Remove temporary lifting angles, lugs, and shipping braces. Touch-up damaged paint finishes.
- C. Caulk seams, cracks, and openings in outdoor enclosures.

3.02 FIELD TESTING

- A. The ISS shall inspect and test the installed equipment prior to energization.

3.03 ADJUSTMENT

- A. The ISS shall make any necessary follow-up or punch list work and technical instruction for the Owner's designated personnel. The ISS shall demonstrate all operational features of the installed instrumentation.

3.04 CLEANING

- A. Remove all rubbish and debris from inside and around the instrumentation. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

3.05 WARRANTY

- A. At a minimum, the Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one (1) year from date of Substantial Completion. Any and all additional warranties that are standard or specifically called out in the Specifications, shall be provided.

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SECTION 13325

CONTROL PANELS AND PANEL MOUNTED EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE

- A. The requirements of Section 13300 Process Instrumentation and Controls shall apply to this section.
- B. Furnish all labor, materials, equipment and incidentals required, to install, complete and ready for operation, the panels depicted on the Drawings and on the Instrumentation Details provided.
- C. Related Work Specified Elsewhere
 - 1. Division 1 – General Requirements;
 - 2. Section 13300 – Process Instrumentation and Controls;
 - 3. Section 13310 – Programmable Logic Controller (PLC) and Digital Equipment;
 - 4. Section 13315 – Field Instrumentation;
 - 5. Section 13320 – Control System Programming;
 - 6. Section 13325 – Control Panels and Panel Mounted Equipment;
 - 7. Division 16 – Electrical;
- D. Provide complete lightning and surge protection per Section 16709 – Protectors and Surge Protection Devices (SPDs) on all control panels and panel mounted equipment for power, communication and signal.

1.02 REFERENCES

- A. Refer to Section 13300 Process Instrumentation and Controls for specifics.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with the General Conditions and Section 01420.
- B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hard copy and two sets of electronic media shall be provided.

- C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
- D. Refer to Section 13300 - Process Instrumentation and Controls for specifics.

1.04 QUALITY ASSURANCE

- A. The Manufacturer of this equipment shall have a minimum of ten (10) years consecutive experience producing similar equipment.
- B. The Manufacturer shall be ISO certified.
- C. UL Listing Requirements
 - 1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
 - 2. The Field Instrumentation shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Enter the code into Category Code search box and click Search.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Deliver product(s) in factory labeled packages.
- B. Handling and shipment of the equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in controller and if necessary, apply temporary heat where required to obtain suitable service conditions.
- D. If panels are to be shipped, the panels shall be mounted on wood skids four inches high. Adequate crating shall be provided for the panel being shipped where a transfer from one truck to another is planned.
- E. If instruments are to be shipped, the instruments shall be blocked and tied to prevent damage during shipment. Front panel mounting instruments shall be removed and repacked in their original containers for shipment.
- F. Accessories, drawings, instruction bulletins, etc., shall be packed and shipped with the panel.

1.06. SPARE PARTS

- A. In addition to the spare parts listed in Section 13300 - Process Instrumentation and Controls, provide the following spares and consumables, packed in a manner suitable for long term storage and adequately protected against corrosion, humidity and temperature:
 - 1. Molded Case Circuit Breakers (MCCBs): 10 percent of each size and type use, but no less than 2 of each size and type.
 - 2. Miniature Circuit Breakers (MCBs): 10 percent of each size and type use, but no less than 2 of each size and type.
 - 3. DC Power Supplies: a minimum of two Owner Standard, minimum 5A power supplies; and any DC Power Supply used shall be provided.

PART 2 - PRODUCTS

2.01. GENERAL

- A. Refer to Section 13300 Process Instrumentation and Controls for specifics.

2.02. LIGHTNING AND SURGE PROTECTION

- A. Refer to Section 13300 - Process Instrumentation and Controls for specifics.
- B. Refer to Section 16709 - Protectors and Surge Protection Devices (SPDs) for specifics.

2.03. CONTROL PANEL GENERAL REQUIREMENTS

- A. Furnish and install the control panels per Specifications and Drawings.
- B. The construction and wiring shall be in accordance with this Specification and applicable panel drawings. The panel drawings will specify the arrangement of instruments to be mounted on the front and rear of the panels.
- C. All openings provided for conduit connections in the field shall be of standard dimensions and comply with UL 514B Standard for Conduit, Tubing and Cable Fittings;
- D. Unless otherwise specified on applicable panel drawings, all panels shall be of the fully enclosed type designed for use with high density instrumentation mounting.
- E. All panel doors shall have a lock installed in the door handle. Locks for each local panel provided under this Contract shall be keyed alike.

- F. The instruments designated for rear of panel mounting shall be arranged within the panel according to respective panel drawings and in a manner to allow for ease of maintenance and adjustment.
- G. Conductors running from the field to the panels shall be continuous without splices, except at approved junction boxes. The junction boxes shall have terminal blocks with minimum 20% spare terminals. Special care shall be exercised to carry grounding lines through such junction boxes with the least possible resistance. Conduit entering panels shall be sealed to prevent the intrusion of gas and moisture. Any aluminum or solid-conductor cables are NOT acceptable.
- H. All components shall be mounted in a manner that shall permit servicing, adjustment, testing and removal without disconnecting, moving or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates, and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Mounting orientation shall be in accordance with the requirements of each component.
- I. No fuses are acceptable unless approved by the Owner.
- J. No relays are acceptable unless approved by the Owner. The sole exception is a dry-contact/coil to monitor bus power.
- K. The internal framework of each panel shall permit panel lifting without racking or distortion. Provide removable lifting rings designed to facilitate simple, safe rigging and lifting of the control panels during installation. Plugs shall be provided and shall unobtrusively fill the panel lifting ring holes when substituted for the lifting rings after installation is complete.
- L. All exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc. required to maintain the NEMA or UL rating of the panel.
- M. All panels shall be supplied with suitable nameplates that identify the panel. Nameplates shall be constructed of white and black laminated, phenolic material having engraved Micarta letters approximately 1/2" high, extending through the white face into the black layer. Nameplates shall be beveled and attached to panels securely.

2.04. CONTROL PANEL MATERIALS AND CONSTRUCTION

A. General

- 1. NEMA 12 (dust-tight, intended for indoor use primarily to provide protection against circulating dust, falling dirt and dripping non-corrosive liquids). Unless otherwise specified, all panels located in air conditioned, indoor, non-process areas shall be of NEMA 12 construction. Wall, channel-mounted or free-standing enclosures shall meet the following:

2. Type 316 Stainless Steel;
3. Continuous Hinge Door(s) with 3-Point Latch(es),
4. 80% minimum of panel interior exposed by doors;
5. Equipped with built in hand-switch controlled, single tube, 40-watt LED light, 1 per door;
6. 120V, 15A duplex utility receptacle, serviced through a dedicated breaker;
7. Equipped with a print pocket;
8. 12-in. (305-mm) floor stands for free-standing enclosures;
9. Enclosures are unpainted. Front, sides, top and back have smooth #4 brushed finished;
10. NEMA 4X (watertight, intended for indoor or outdoor use to provide protection against windblown dust and rain, splashing rain, hose-directed water, and damage from external ice formation). Unless otherwise specified, all panels located outdoor or indoor process areas shall be of NEMA 4X construction. Wall, channel-mounted or free-standing enclosures shall meet the following:
 11. Type 316 Stainless Steel;
 12. Continuous Hinge Door(s) with 3-Point Latch(es),
 13. 80% minimum of panel interior exposed by doors;
 14. Equipped with built in hand-switch controlled, single tube, 40-watt LED light, 1 per door;
 15. 120V, 15A duplex utility receptacle, serviced through a dedicated breaker;
 16. Equipped with a print pocket;
 17. 12-in. (305-mm) floor stands for free-standing enclosures;
 18. Enclosures are unpainted. Front, sides, top and back have smooth #4 brushed finished;
 19. Seams continuously welded and ground smooth; no holes or knockouts;
 20. Equipped with full sun shields as specified in 13325-2.05
 21. Provide explosion-proof enclosures where required in hazardous areas.

22. Panels shall be provided with full length, fully gasketed doors as shown on the panel details. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments. All doors shall open a minimum of 90 degrees.
23. Refer to panel details and other Drawings for approximate panel size and equipment layout.
24. The panel shall be suitable for bottom conduit entry as required by the Electrical Drawings. No top penetrations unless specifically approved by the owner. All conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, or other accessories as required maintaining the NEMA rating of the panel and electrical rating of the conduit system.
25. Support Structures. Do not use expansive screw anchors, shields, or other fastening items containing lead or other material that might loosen or melt under fire conditions. Do not use power-actuated fasteners and devices.
26. All sections SHALL BE DE-SCALED, DEGREASED, FILLED, GROUND AND FINISHED.

B. Acceptable Control Panel Enclosure Manufacturers

1. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com
 - a. NEMA 12
 - 1) Concept® Type 12 Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch;
 - 2) Type 12 Free-Stand Enclosures; Type 12 Floor-Mount Enclosures; all with 3-Point Latches;
 - b. NEMA 4X
 - 1) Stainless Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch; Or
 - 2) Stainless Steel Free-Standing Single or Dual Access Enclosures with 3-Point Latches
2. RITTAL CORP. / www.rittal.com
 - a. NEMA 12
 - 1) Compact AE Single or Double Door Enclosures, Continuous Hinge with 3-point Latch; or

2) TS 8 Baying Systems;

b. NEMA 4X

1) WM Wall-mount Enclosures with Accessory Part No. WMLHKLS6 – 8018691 L Handle for WM 3 Point Latch, Pad-lockable, Stainless Steel 316L

3. OWNER PREAPPROVED EQUAL

2.05 CONTROL PANEL TEMPERATURE CONTROL

- A. The internal temperature of all panels shall be regulated so as not to exceed 100 degrees Fahrenheit. Under no circumstances shall the panel cooling equipment compromise the NEMA rating of the panel.
- B. NEMA 4X rated panels that are exposed to sunlight shall be equipped with adequate sunshields. The sunshield shall consist of one or more pieces of Type 316 Steel of sufficient size to cover the top, sides, and rear of the panel (where applicable), and to hang over the front of the panel to shade any instruments mounted there. Sunshield pieces shall be powder coat painted white. Sunshield pieces shall be secured to the panel by bolts and shall have no less than 2-inches of clearance from the panel and from one another, to allow for air circulation over the sunshield surfaces.
- C. Should sufficient heat be generated within a panel where dissipation cannot be adequately accomplished with natural convection, cooling shall be provided;
- D. Acceptable Control Panel Climate Control Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com
 - a. Thermal Management Products Corrosive/Outdoor Series CR29
 - 2. RITTAL CORP. / www.rittal.com
 - b. System Climate Control Products;
 - 3. PFANNENBERG INCORPORATED / www.pfannenberguna.com
 - a. Stainless Steel (304) / Wash down 4/4X Cooling Units;
 - b. Legacy panels
 - c. Cooling Unit, 2000BTU/HR, Side-Mount, 304SS, 115/230-VAC, Thermostat controlled, Corrosive resistant, NEMA 4X,
 - d. Part No. 13340214300;

4. OWNER PREAPPROVED EQUAL

2.06 CONTROL PANEL INTERNAL CONSTRUCTION

A. Internal Electrical Wiring

1. Panel equipment shall be mounted and wired on or within the cabinet. Wiring shall comply with the National Electrical Code. Wiring within the panel shall be grouped together with harnesses or ducts and secured to the structure. Wiring shall be numbered in compliance with the numbering system used on the wiring/connection diagrams. Wiring and connection diagrams shall comply with ISA-5.4 (Instrument Loop Diagrams) and shall be submitted by the manufacturer as part of the Shop Drawings for review by the Engineer and City. For specific conductors, communication cable, and connectors, reference division 16 section 16120, "Wires and Cables- 600 volts and less";
2. All conductors shall be UL-listed Type UL 1015/1063 AWM/MTW/TEW, 105°C, gasoline and oil resistant, suitable for operation at 600 volts. Conductors shall be annealed tinned copper, insulated with high-heat, moisture resistant, polymer PVC with abrasion, moisture, gasoline and oil resistant nylon jacket.
3. Conductor Color Coding shall be as follows:
 - a. 120VAC Line power Panel Supply Source - Black;
 - b. 120VAC Neutral Panel Supply Source - White;
 - c. 120VAC Control and Power Wiring from a Control Power Transformer - Red;
 - d. 120VAC Control and Power Wiring from a Uninterrupted Power Supply source (UPS) - Red
 - e. 120VAC Neutral Control and Power Wiring from a Control Power Transformer - White with Red Stripe;
 - f. 120VAC Neutral Control and Power Wiring from a Uninterrupted Power Supply source (UPS) - White with Red Stripe;
 - g. 120VAC Ground - Green;
 - h. 120VAC Control and Power Wiring Line Power from an external source - Orange;
 - i. 120VAC Neutral Control and Power Wiring Line Power from an external source- White with an Orange stripe;
 - j. +24VDC - Blue;

- k. -24VDC – Grey;
 - l. +48VDC – Blue/Red Stripe;
 - m. -48VDC – Grey/White Stripe;
 - n. Discrete Input Module to Surge Protection Device Field Terminal Block – Red;
 - o. Discrete/Relay Output Module to Surge Protection Device Field Terminal Block – Yellow;
 - p. Analog I/O Module to Surge Protection Device Field Terminal Block –Black (-), White (+), Green (-), Red (+);
 - q. RTD Module to Surge Protection Device Field Terminal Block - Black (-), White (+), Green (-), Red (+);
4. Serial Communications – Twisted pair, low capacitance computer cable;
- a. RS485 (MODBUS, CAN, etc.)- White/Blue(+), Blue/White(-);
 - b. RS232 (MODBUS, etc.)- Red(+), Black(-);
 - c. PROFIBUS® DP™ – Red (A1), Green (B1);
 - d. Can Bus- Black (Ground), Red (Can High), White (Can Low)
 - e. PROFINET™ Network- Green jacket;
 - f. ETHERNET Network- Blue jacket;
5. Conductor Size minimums and cable types shall be as follows:
- a. Line Power Panel Supply Source Wiring -14 AWG;
 - b. UPS Power Supply Source Wiring-14 AWG;
 - c. Control Power Supply Source-16 AWG;
 - d. External Control Power Supply Source-16 AWG;
 - e. 24 and 48vdc control wiring-16 AWG;
 - f. Discrete Input Module wiring-16AWG;
 - g. Discrete /Relay Output Module wiring-16AWG;

- h. Analog Input and Output Module Wiring- paired individual shielded, twisted, 18 AWG, stranded cable;
 - i. RTD Input Module Wiring- 4 conductor, twisted, 18 AWG, stranded shielded cable;
 - j. Profinet and Ethernet Network Communications- IE FC TP Standard Cable AWG 24 ;
 - k. Profibus DP, 22 Awg, 2 conductor, twisted, stranded, shield
 - l. Control and Power wiring size requirements shall be determined by the load and protected in accordance to requirements of : NEC Article 240, NFPA79 and UL508A;
 - m. RS485 - 24AWG
 - n. RS232 - 24AWG
 - o. Can Bus - 20AWG
6. Wiring shall terminate at a master terminal board, rigid type and numbered. The master terminal board shall have a minimum of 20 percent spares.
 7. Terminal blocks shall be arranged in vertical rows and separated into groups (Power, AC control, DC signal, and alarm). Terminal strips shall be provided for the purpose of connecting all control and signal wiring. Terminal blocks shall be SIEMENS 8WA1, or City approved equal with the appropriate voltage rating (600 volts minimum).
 8. Each group of discrete loops for a common piece of equipment shall be protected by circuit breaker.
 9. Wiring trough for supporting internal wiring shall be plastic type with snap on covers. The sidewalls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the sub panel by using stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.
 10. Each wire shall be provided with a numbered heat shrink tubing identification marker, with the same number at both ends. Numbering shall be in accordance with the Control Panel Drawings and shall include the instrument Loop Number. Identification markers shall be pre-typed. Handwritten markers or paper markers will not be permitted.
 11. Direct interlock wiring between equipment will not be allowed. Only one side of a terminal block row shall be used for internal wiring.
 12. Wiring troughs shall not be filled to more than 60 percent visible fill.

13. All Control panels shall include a lighting fixture for each door. Each shall be a single tube, LED light fixture, mounted internally to the ceiling of the panel. Light fixture shall be switched and shall be complete with the lamp.
14. Each panel shall have a surge protected dual outlet for 120 VAC, 15A service receptacle (HUBBELL® DRUBTVSS15, PHOENIX CONTACT EM-DUO-120/15/SPD, or City approved equal) mounted internally within a stamped steel device box with appropriate cover.
15. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.
16. Each panel shall be provided with a separate copper power grounding bus for safety (SIEMENS ECGB Series, SQUARE D® PK7GTA, or City approved equal) in accordance with the requirements of the National Electrical Code.
17. Each panel shall be provided with surge suppression protection (electrical transients) for connections between AC power systems and electrical and electronic equipment. Surge suppressor grounding shall be in accordance with the manufacturer's recommendations. Refer to Section 13300.
18. All discrete (input and output) signals and all analog (input and output) signals shall have individually surge suppression protection at both ends. Refer to Section 13300.
19. Each panel shall be provided with a power disconnect breaker.
20. All wiring to hand switches and the like which are live circuits independent of the panel's normal circuit breaker protection shall be clearly identified as such.
21. Panels shall have an initial installed capacity of I/O (terminal blocks, surge suppressors, interposing relays) as shown on drawings and as described in the specification sections plus 20 percent installed spares and capacity for 20 percent input/output expansion within the enclosures provided.
22. B. Print Storage Pockets shall be provided and used on the inside of each panel. Its size shall be sufficient to hold all of the prints required to service the equipment.

2.07 CONTROL PANEL ENCLOSURE CORROSION INHIBITING VAPOR CAPSULES

- A. Vapor capsules emit powerful corrosion inhibiting molecules into an enclosure that settle on metal surfaces and protect them from corrosion;
- B. Acceptable Control Panel Enclosure Corrosion Inhibiting Vapor Capsule Manufacturers
 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com

- a. Industrial Corrosion Inhibitors, Part No. A-HClxxxx;
- 2. NORTHERN TECHNOLOGIES INT'L CORP. / www.ntic.com
 - a. Part No. Zerust® ICT® VCx-x;
- 3. OWNER PREAPPROVED EQUAL

2.08 CONTROL PANEL ENCLOSURE CORROSION INHIBITOR EMITTER

- A. Emitters are unique devices designed to provide corrosion protection for metal components and parts enclosed in non-ventilated control boxes, cabinetry or tool boxes. These devices emit vapors, which deposit a molecular layer on internal metal surfaces to protect critical, complex and expensive electronic equipment during operation, shipping or storage. Provides long-term protection against corrosion even in the presence of adverse conditions including salt, moisture, airborne contaminants, H₂S, SO₂, NH₃ and others.
- B. Acceptable Control Panel Enclosure Corrosion Inhibitor Emitter Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com
 - a. Industrial Corrosion Inhibitors, Part No. A-HC15E;
 - 2. CORTEC® CORPORATION / www.cortecvci.com
 - a. Vapor phase Corrosion Inhibitors, Part No. VpCI-111;
 - 3. OWNER PREAPPROVED EQUAL

2.09 CONTROL PANEL ENCLOSURE VENT DRAINS

- A. These devices provide ventilation to minimize condensation; drain any accumulated condensate; equalize pressure;
- B. Acceptable Control Panel Enclosure Vent Drain Manufacturers
 - 1. COOPER / www.crouse-hinds.com
 - a. CROUSE-HINDS®, PART NO. ECD18;
 - 2. EGS ELECTRICAL GROUP / www.appletonelec.com
 - a. APPLETON® Stainless Steel Breather 4X, Part No. BRTB4X;
 - b. Stainless Steel Drain 4X, Part No. ECD50B4X;
 - 3. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com

- a. H2OMIT® Non-Metallic Vent Drain, Type 4X, Part No. AVDR4NM;
- b. ABS Plastic Pressure Compensation Device, Type 4X,
- c. Part No. APCDABS; Vent/Drain must be mounted in bottom of enclosure;
- d. Pressure Compensation Device, ABS plastic,
- e. Semi-permeable membrane inside the plug filters moisture and dust;

4. OWNER PREAPPROVED EQUAL

2.10 CONTROL PANEL ENCLOSURE LED LIGHTING FIXTURES

- A. All control panels shall include a lighting fixture for each door;
- B. Acceptable Control Panel Enclosure LED Lighting Fixtures Manufacturers
 - 1. PENTAIR TECHNICAL PRODUCTS HOFFMAN® / www.hoffmanonline.com
 - a. PANELITE™ LED Enclosure Light, Part No. LED24V15;
 - 2. RITTAL CORP. / www.rittal.com
 - a. 10/20/30/40-LED SYSTEM LIGHTS, PART NO. 4140810, 4140820, 4140830, OR 4140840;
 - 3. OWNER PREAPPROVED EQUAL

2.11 CONTROL PANEL ENCLOSURE WINDOW KITS

- A. Windows kits allow for safe and easy visual access to internal control panel components without compromising the NEMA rating of the enclosure.
- B. Acceptable Control Panel Enclosure Window Kit ManufacturerS
 - 1. CARLON® / www.carlon.com
 - a. Circuit Safe® NEMA 4X Rated Window Kits;
 - b. CARLON NI86W/NI88W OR FIBOX IPW2819 CAN BE USED FOR A MM440 AOP;
 - 2. FIBOX ENCLOSURES / www.fiboxusa.com
 - a. Inspection Windows or
 - b. Instrument Protection Windows;

3. OWNER PREAPPROVED EQUAL

2.12 CONTROL PANEL ENCLOSURE HUBS

A. Requirements:

1. Hub body & nut material shall be same as enclosure;
2. Ground Hub usage per NEC;
3. Sized correctly;
4. Vibration proof;
5. Captive o-ring gasket;
6. UL Type rated;
7. NEMA Type rated;

B. Acceptable Control Panel Enclosure Hub Manufacturers

1. COOPER / www.crouse-hinds.com
 - a. Myers™ Hubs
2. CALBRITE™ / www.calbrite.com
 - a. Stainless Steel Line Hubs
3. OWNER PREAPPROVED EQUAL

2.13 CONTROL PANEL ENCLOSURE CORD CONNECTORS

A. Requirements:

1. Sized correctly;
2. UL Listed;
3. NEMA or UL Type rated;

B. Acceptable Control Panel Enclosure Cord Connector Manufacturers

1. HUBBELL® / www.hubbell.com
 - a. Kellems® Straight Male Cord Connectors
2. REMKE INDUSTRIES / www.remke.com

- a. Tuff-Seal™ RSSS Series
 - 3. CALBRITE™ / www.calbrite.com
 - a. Cord Grip Connectors
 - 4. OWNER PREAPPROVED EQUAL
- 2.14 CONTROL PANEL ENCLOSURE DISCONNECT, DOOR MOUNTED
- A. UL Listed;
 - B. Acceptable Control Panel Enclosure Disconnect, Door Mounted Manufacturers
 - 1. SIEMENS INDUSTRY / www.sea.siemens.com
 - a. Max-Flex™ Flange Mounted Variable Depth Operators;
 - 2. OWNER PREAPPROVED EQUAL
- 2.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)
- A. The power supplied to all microprocessor-based equipment (PLCs, loop controllers, manual loading stations, etc.) in the control panel shall be protected by an Uninterruptible Power Supply (UPS). UPS shall prevent spikes, sags, surges, noise, and harmonics from adversely affecting equipment. UPS input and output shall be galvanically isolated from one another.
 - B. UPS shall contain internal backup batteries (and/or external battery module(s)) sufficient to allow all connected equipment to run continuously for no less than 60 minutes at full panel load. Provide load calculations that show these requirements are met.
 - C. UPS shall be a true online UPS with zero switch time, using a continuous no-break connection to ensure no momentary power interruptions.
 - D. Control Panels containing an Ethernet connected PLC shall include an AC UPS, input and output power shall be 120VAC, 60 Hz. UPS shall be network-ready for remote control & monitoring (real-time status and battery statistics) using the manufacturer's standard interface card installed to communicate with the City's Network (100Mb minimum Ethernet IEEE 802.3 TCP/IP; connected by CAT6e cable with RJ-45 connectors; SNMP capable).
 - E. Lift station Control Panels with an RTU not connected via Ethernet shall contain a DC-UPS to provide a minimum of +100 minutes of battery runtime at 50% load; DC-UPS Batteries shall be maintenance-free chemical lead-acid batteries rated -40 to +140 °F (-40 to +60 °C) ambient temperature range;

F. ANY instrumentation/device panels and/or air-conditioned office locations required to remain powered throughout temporary power interruptions shall use a SCHNEIDER ELECTRIC APC Back-UPS Pro 1300.

G. Acceptable UPS Manufacturers

1. EATON CORPORATION / www.powerware.com

- a. EATON 9SX1000 1000VA, 120VAC; Part No. 9SX1000;
- b. SNMP/Web Network-M2 Card, Part No. 744-A3983; and
- c. Extended Battery Pack, Part No. 9SXEBM36;
- d. PLC, Uninterruptible Power Supply (UPS) - Network-ready for remote control & monitoring (real-time UPS status and battery statistics); USED IN INDUSTRIAL ENVIRONMENTS;

2. SCHNEIDER ELECTRIC AMERICAN POWER CONVERSION CORP. / www.apc.com

- a. APC Power-Saving Back-UPS Pro 1300, 780W / 1300VA, Part No. BR1300G;
- b. Uninterruptible Power Supply (UPS) – 3-Year Warranty, under \$200, 1.3kVA, 10 outlets (5 battery / 5 surge); USED IN OFFICE ENVIRONMENTS;

3. SIEMENS INDUSTRY / www.automation.siemens.com

- a. DC-UPS 24VDC/6A Controller, Part No. 6EP1 931-2DC21; or
- b. DC-UPS 24VDC/15A Controller, Part No. 6EP1 931-2EC21; and
- c. DC-UPS 2.5Ah High Temperature Rechargeable Battery, Part No. 6EP 935-6MD31;
- d. RIO, Uninterruptible Power Supply (UPS) with Line Power Fail and Battery Fail Contacts;
- e. Requires 24VDC Power Supply;
- f. Battery module contains two maintenance-free, sealed lead-acid batteries;

2.16 BUFFER MODULE

A. With short-term power failures, the load current can be backed up without interruption via the buffer module in combination with the power supply. The buffer module is

connected in parallel to the output of the power supply; Used in ALL PLC Panels in UPS Circuit; UL Listed;

B. Acceptable Buffer Module Manufacturers

1. SIEMENS INDUSTRY / www.automation.siemens.com
 - a. SITOP Buffer Module, Part No. 6EP1 961-3BA00;
 - b. Use Puls SLZ12 Bracket Adapter to S7 Rail;
 - c. NO EQUAL

2.17 MISCELLANEOUS PANEL COMPONENTS

- A. Pushbuttons, Indicating Lights and Selector Switches are referenced in 16050-2.36.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The panels shall be installed at locations as shown on the Contract Drawings.
- B. Panels shall be factory tested prior to shipment. Field installation shall consist of setting the panel in place, making necessary electrical and conduit connections and connecting the field devices and instrumentation.
- C. Refer to Section 13300 - Process Instrumentation and Controls for specifics.

3.02 GENERAL TESTS

- A. Prior to shipment, a documented factory test shall be performed at the factory, or other selected site, on panels provided. The test shall demonstrate specified functions by simulating inputs and outputs to the panels. Final test documents shall be provided to Owner for review and approval.
- B. Acceptance of shop tests by the Owner shall not constitute a waiver of requirements to meet the field tests under specified operating conditions, nor does inspection relieve the Manufacturer of his responsibility in any way.
- C. Refer to Section 13300 - Process Instrumentation and Controls for specifics.

3.04 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service.
- B. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.

- C. Verify that all panels and devices are installed and connected according to the Contract Documents.
- D. Coordinate with owner to verify that all required communication and SCADA related integration is complete according to the Contract Documents;
- E. Verify that electrical and control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing;
- F. Verify that wiring installation complies with requirements in Division 13 and 16 Sections;
- G. Complete installation and startup checks according to Manufacturer's written instructions.

3.05 WARRANTY

- A. Refer to Section 13300 Process Instrumentation and Controls for specifics.

- END OF SECTION -

SECTION 15000

BASIC MECHANICAL REQUIREMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install to the required line and grade, all piping together with all fittings and appurtenances, required for a complete installation. Piping to be backfilled and/or encased in concrete is considered to be buried piping. Piping that is not buried is considered to be exposed.
- B. The Contractor shall furnish and install fittings, couplings, connections, sleeves, adapters, harness rods and closure pieces as required to connect pipelines of dissimilar materials and/or sizes herein included under this Section and other concurrent Contracts for a complete installation.
- C. The Contractor shall furnish all labor, materials, equipment, tools, and services required for the furnishing, installation and testing of all piping as shown on the Drawings, specified in this Section and required for the Work. Piping shall be furnished and installed of the material, sizes, classes, and at the locations shown on the Drawings and/or designated in this Section. Piping shall include all fittings, adapter pieces, couplings, closure pieces, harnessing rods, hardware, bolts, gaskets, wall sleeves, wall pipes, hangers, supports, and other associated appurtenances for required connections to equipment, valves, or structures for a complete installation.
- D. Piping assemblies under 4-inch size shall be generally supported on walls and ceilings, unless otherwise shown on the Drawings or ordered by the Engineer, being kept clear of openings and positioned above "headroom" space. Where practical, such piping shall be run in neat clusters, plumb and level along walls, and parallel to overhead beams.
- E. The Contractor shall provide taps on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, a boss or pipe saddle shall be installed.
- F. The work shall include, but not be limited to, the following:
 - 1. Connections to existing pipelines.
 - 2. Test excavations necessary to locate or verify existing pipe and appurtenances.
 - 3. Installation of all new pipe and materials required for a complete installation.
 - 4. Cleaning, testing, and disinfecting as required.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 1 – General Requirements
- B. Division 2 – Sitework
- C. Division 5 – Metals
- D. Division 9 – Finishes
- E. Division 11 – Equipment General Provisions
- F. Division 16 – Electrical

1.03 MATERIAL CERTIFICATION AND SHOP DRAWINGS

- A. The Contractor shall furnish to the Owner (through the Engineer) a Material Certification stating that the pipe materials and specials furnished under this Section conform to all applicable provisions of the corresponding Specifications. Specifically, the Certification shall state compliance with the applicable standards (ASTM, AWWA, etc.) for fabrication and testing.
- B. Shop Drawings for major piping (2-inches in diameter and greater) shall be prepared and submitted in accordance with Section 01300 – Submittals. In addition to the requirements of Section 01300 – Submittals, the Contractor shall submit laying schedules and detailed Drawings in plan and profile for all piping as specified and shown on the Drawings.
- C. Shop Drawings shall include, but not be limited to, complete piping layout, pipe material, sizes, class, locations, necessary dimensions, elevations, supports, hanger details, pipe joints, and the details of fittings including methods of joint restraint. No fabrication or installation shall begin until Shop Drawings are approved by the Engineer.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All specials and every length of pipe shall be marked with the manufacturer's name or trademark, size, class, and the date of manufacture. Special care in handling shall be exercised during delivery, distribution, and storage of pipe to avoid damage and unnecessary stresses. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.
- B. Testing of pipe before installation shall be as described in the corresponding ASTM or AWWA Specifications and in the applicable standard specifications listed in the following sections. Testing after the pipe is installed shall be as specified in Part 3.

- C. Joints in piping shall be of the type as specified in the appropriate Piping System Schedule in Section 15390 – Pipe Schedules.
- D. All buried piping shall have restrained joints for thrust protection unless otherwise specified or shown on the Drawings. All exposed piping shall have flanged joints, unless otherwise specified or shown on the Drawings.
- E. The Drawings indicate work affecting existing piping and appurtenances. The Contractor shall excavate test pits as required of all connections and crossings which may affect the Contractor's work prior to ordering pipe and fittings to determine sufficient information for ordering materials. The Contractor shall take whatever measurements that are required to complete the work as shown or specified.

2.02 WALL PIPES

- A. Where wall sleeves or wall pipes occur in walls that are continuously wet on one or both sides, they shall have water stop flanges at the center of the casting or as shown on the Drawings. Ends of wall pipes shall be flange, mechanical joint, plain end, or bell as shown on the Drawings, or as required for connection to the piping. Wall pipes shall be of the same material as the piping that they are connected to. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange. Unless otherwise shown on the Drawings, waterstop flanges shall conform to the minimum dimensions shown below:

Pipe Size	Waterstop Flange Diameter	Waterstop Flange Thickness
4" - 12"	OD + 3.10"	0.50"
14" - 24"	OD + 4.15"	0.75"
30" - 36"	OD + 4.50"	1.00"
42" - 48"	OD + 5.00"	1.25"

2.03 SLEEVES

- A. Unless shown otherwise, all piping passing through walls and floors shall be installed in sleeves or wall castings accurately located before concrete is poured or placed in position during construction of masonry walls. Sleeves passing through floors shall extend from the bottom of the floor to a point 3 inches above the finished floor, unless shown otherwise. Water stop flanges are required on all sleeves located in floors or walls which are continually wet or under hydrostatic pressure on one or both sides of the floor or wall.
- B. Sleeves shall be cast iron, black steel pipe, or fabricated steel in accordance with details shown on the Drawings. If not shown on the Drawings, the Contractor shall submit to the Engineer the details of sleeves they propose to install; and no fabrication or installation thereof shall take place until the Engineer's approval is obtained. Steel sleeves shall be fabricated of structural steel plate in accordance with the standards and procedures of

AISC and AWS. Steel sleeve surfaces shall receive a commercial sandblast cleaning and then be shop painted in accordance with Section 09900 – Painting.

- C. When shown on the Drawings or otherwise required, the annular space between the installed piping and sleeve shall be completely sealed against a maximum hydrostatic pressure of 20 psig. Seals shall be mechanically interlocked, solid rubber links, trade name "Link-Seal", as manufactured by Garlock Pipeline Technologies (GPT) or equal. Rubber link, seal-type, size, and installation thereof, shall be in strict accordance with the manufacturer's recommendations. For non-fire rated walls and floors, pressure plate shall be glass reinforced nylon plastic with EPDM rubber seal and 316 stainless steel bolts and nuts. For fire rated walls and floors, two independent seals shall be provided consisting of low carbon steel, zinc galvanized pressure plates, silicon rubber seals and 316 stainless steel bolts and nuts.
- D. Cast iron mechanical joint adapter sleeves shall be Clow # 1429, as manufactured by the Clow Corp., or equal. Mechanical joint adapter sleeves shall be provided with suitable gasket, follower ring, and bolts to affect a proper seal. In general, sleeves installed in walls, floors, or roofs against one side of which will develop a hydrostatic pressure, or through which leakage of liquid will occur, shall be so sealed. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange.

2.04 SOLID SLEEVE COUPLINGS (FOR BURIED SERVICE THROUGH 54-INCH)

- A. Solid sleeve couplings shall be used to connect buried service piping where shown on the Drawings. Solid sleeves shall be ductile iron, long body and shall conform to the requirements of ANSI A21.10 (AWWA C110). Unless otherwise shown or specified, solid sleeve couplings shall be Style A11760 as manufactured by American Cast Iron Pipe Co., or equal. Solid sleeve couplings shall be restrained with wedge-type restraining glands to meet the pressures specified in Section 15390 –Pipe Schedules.
- B. Alternatively, EBAA Iron 3800 Mega-Coupling is acceptable.

2.05 FLANGED COUPLING ADAPTERS

- A. Flanged coupling adapters shall be furnished as required and as shown on the Drawings.
- B. Flanged coupling adapters shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. All flanged coupling adapters shall be harnessed by tying the adapter to the nearest pipe joint flange using threaded rods and rod tabs unless otherwise approved by the Engineer.
- D. Flanged coupling adapters shall be manufactured by Smith-Blair Model 912 or 913, Romac Industries Model FCG or FC 400, Dresser Industries Model 128-W, or equal.
- E. Flanged coupling adapters shall be provided with manufacturer's fusion bonded epoxy painting system.

2.06 DISMANTLING JOINTS

- A. Dismantling joints shall be furnished at locations shown on the Drawings.
- B. Dismantling joints for sizes less than 12-inch shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping. Dismantling joints for sizes greater than 12-inches shall be of carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. Flanges for dismantling joints shall match the bolt pattern and pressure rating of the flanges for the connected piping.
- D. All dismantling joints shall be restrained utilizing restraining rods provided by the manufacturer. Restraining rods shall be constructed from ASTM A193 Grade B7 steel. Restraining rods and restraint system shall be installed in strict accordance with manufacturer's recommendations.
- E. Dismantling joints shall be provided with manufacturer's fusion bonded epoxy painting system.
- F. Dismantling joints shall be manufactured by Smith Blair Model 975, Romac Industries Model DJ400, or equal.

2.07 GROOVED COUPLINGS

- A. Grooved end pipe couplings shall be furnished as specified or shown on the Drawings.
- B. Materials shall be of malleable iron and couplings shall be rated for the same pressures as the connecting piping.
- C. Gaskets shall be rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated.
- D. After installation, buried couplings shall receive two heavy coats of an approved coal tar which is compatible with the finish of the coupling. Exposed couplings shall be painted in accordance with Section 09900 – Painting.
- E. Couplings shall be manufactured by Victaulic Company of America Style 31 or equal.

2.08 TAPPING SLEEVES AND TAPPING SADDLES

- A. Tapping sleeves may only be used if required during construction. Tapping sleeves and valves shall be a joint type with flanged outlet per ANSI B 16.1, Class 125 manufactured by Dresser Industries, Inc., Anniston, Alabama or as approved by the Owner. Sleeve shall be stainless steel with stainless steel hardware. All sleeves shall have a minimum working pressure of 150 psi. All sleeves larger than twelve (12) inches shall be ductile iron. All taps shall be machine drilled; no burned taps will be allowed. The tapping valve shall be installed horizontally. An isolation valve (plug valve) shall be installed adjacent to the

tapping Valve. Tapping valves shall be gate valves specially designed for wet tapping and compatible with the connecting sleeve and with a sanitary sewer application.

- B. Tapping saddles may only be used if required during construction. Tapping saddles shall be manufactured of ductile iron providing a factor of safety of at least 2.5 at a working pressure of 250 psi. Saddles shall be equipped with a standard AWWA C-110-77 flange connection on the branch. Sealing gaskets shall be "O" ring type, high quality molded rubber having an approximate seventy durometer hardness, placed into a groove on the curved surface of the tapping saddles. Straps shall be of alloy steel. The tapping saddle shall be the American tapping saddle, U.S. Pipe tapping saddle, or equal. All taps shall be machine cut, no burned taps will be allowed. The tapping valve shall be installed horizontally. An isolation valve (plug valve) shall be installed adjacent to the tapping Valve. Tapping valves shall be gate valves specially designed for wet tapping and compatible with the connecting sleeve and with a sanitary sewer application.

2.09 UNIONS

- A. For ductile iron, carbon steel, and grey cast iron pipes assembled with threaded joints and malleable iron fittings, unions shall conform to ANSI B16.39.
- B. For PVC piping, unions shall be socket weld type with Viton O-ring.

2.10 FLEXIBLE RESTRAINED EXPANSION JOINTS

- A. Restrained expansion joints shall be manufactured of 60-42-10 ductile iron conforming to material and other applicable requirements of ANSI/AWWA C153/A21.53.
- B. Each pressure containing component shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the materials requirements of, and tested in accordance with, ANSI/AWWA C213 and shall meet or exceed the requirements of ANSI/AWWA C550.
- C. Seals shall conform to the applicable requirements of ANSI/AWWA C111/A21.11.
- D. All bolts used in the assemblies shall be stainless steel and shall be coated with a premium quality epoxy.
- E. Flanged ends shall comply with ANSI/AWWA C110/A21.10, with the addition of O-ring groove and O-ring.
- F. Mechanical joint ends shall comply with ANSI/AWWA C153/A21.53.
- G. Restrained expansion joints shall have a minimum pressure rating of 350 psi with a minimum safety factor of 3:1. Each assembly shall be tested at 350 psi before shipment.
- H. Restrained expansion joints shall provide for self-restraint without tie rods and shall provide for expansion and contraction capabilities cast as an integral part of the end connection.

- I. Flexible restrained expansion joints shall allow for 8-inches (+6"-2") minimum expansion.
- J. Flexible restrained expansion joints shall consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint having a minimum of 15° deflection per ball.
- K. Restrained expansion joints shall be the Single Ball or Double Ball FLEX-TEND Expansion Joint as manufactured by EBAA Iron Inc., or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All piping shall be installed by skilled workmen and in accordance with the best standard practice for piping installation as shown on the Drawings, specified or recommended by the pipe manufacturer. Proper tools and appliances for the safe and convenient handling and installing of the pipe and fittings shall be used. Great care shall be taken to prevent any pipe coating from being damaged on the inside or outside of the pipe and fittings. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be cracked, damaged, or otherwise defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced with a sound one in a satisfactory manner by the Contractor and at the Contractor's own expense. Pipe and fittings shall be thoroughly cleaned before they are installed and shall be kept clean until they are accepted in the complete work. All piping connections to equipment shall be provided with unions or coupling flanges located so that piping may be readily dismantled from the equipment. At certain applications, Dresser, Victaulic, or equal, couplings may also be used. All piping shall be installed in such a manner that it will be free to expand and contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Unless otherwise shown or approved, provided a minimum headroom clearance under all piping of 7 feet 6 inches.
- B. Unless otherwise shown or specified, all waste and vent piping shall pitch uniformly at a 1/4-inch per foot grade and accessible cleanouts shall be furnished and installed as shown and as required by local building codes. Installed length of waste and vent piping shall be determined from field measurements in lieu of the Drawings.
- C. All excavation shall be made in such a manner and to such widths as will provide ample room for properly installing the pipe and permit thorough compaction of backfill around the pipe. The minimum trench widths shall be in strict accordance with the "Trench Width Excavation Limits" as shown on the Drawings. All excavation and trenching shall be done in strict accordance with these specifications and all applicable parts of the OSHA Regulations, 29CFR 1926, Subpart P.

- D. All excavation required by this contract shall be unclassified. no additional payment will be made for rock excavation required for the installation of pipe or structures shown on the drawings.
- E. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.
- F. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, or obstructions.
- G. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet. The Contractor shall excavate the trenches to the full depth, width and grade indicated on the Drawings including the relevant requirements for bedding. The trench bottoms shall then be examined by the Engineer as to the condition and bearing value before any pipe is laid or bedding is placed.
- H. No pressure testing shall be performed until the pipe has been properly backfilled in place. All pipe passing through walls and/or floors shall be provided with wall pipes or sleeves in accordance with the specifications and the details shown on the Drawings. All wall pipes shall be of ductile iron and shall have a water stop located in the center of the wall. Each wall pipe shall be of the same class, thickness, and interior coating as the piping to which it is joined. All buried wall pipes shall have a coal tar outside coating on exposed surfaces.
- I. Joint deflection shall not exceed 75 percent of the manufacturer's recommended deflection. Excavation and backfilling shall conform to the requirements of Section 02200 – Earthwork, and as specified herein. Maximum trench widths shall conform to the Trench Width Excavation Limits shown on the Drawings. All exposed, submerged, and buried piping shall be adequately supported and braced by means of hangers, concrete piers, pipe supports, or otherwise as may be required by the location.
- J. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall any of the materials be dropped or dumped into the trench.
- K. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fitting, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.

- L. All piping shall be installed in such a manner that it will be free to expand and/or contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Pipes crossing within a vertical distance of less than or equal to one (1) foot shall be encased and supported with concrete at the point of crossing to prevent damage to the adjacent pipes as shown on the Drawings.
- M. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation; and no pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at the Contractor's own expense. Pipe shall not be laid in water or when trench conditions are unsuitable for work.
- N. Proper and suitable tools and appliances for the safe convenient handling and laying of pipe shall be used and shall in general agree with manufacturer's recommendations.
- O. At the close of each workday, the end of the pipeline shall be tightly sealed with a cap or plug so that no water, dirt, or other foreign substance may enter the pipeline, and this plug shall be kept in place until pipe laying is resumed.
- P. During the laying of pipe, each pipe manufacturer shall provide their own supervisor to instruct the Contractor's pipe laying personnel in the correct procedure to be followed.
- Q. Ordinarily only full lengths of pipe (as furnished by the pipe manufacturer) shall be used. Exceptions: closure pieces at manholes and areas where joint deflection is required.
- R. For gravity sewer installations, the Contractor shall use a laser device to maintain the trench and pipe alignment. The laser device shall be re-checked for correct elevation and pipe alignment prior to pipe installation if the device is left in the pipe overnight. Corrected invert elevations at each manhole and any adjustments will be coordinated and approved by the Engineer.
- S. All piping shall have type "a" bedding as shown on the drawings, unless otherwise specified herein or indicated on the drawings.
- T. Detector tape shall be installed 12 inches below final grade and directly above all buried potable water piping. The tape shall be blue and silver and shall be clearly and permanently labeled "Water". Detector tape shall be Lineguard III as manufactured by Lineguard, Inc., or equal.
- U. At the close of work each day, pipeline trenches shall be completely backfilled. in paved areas the surface shall be restored as specified in Section 02510 – Paving and Surfacing,

to allow for traffic over the trench during non-working hours. under no conditions shall any pipeline trench be left open during non-working hours.

3.02 JOINTS IN PIPING

- A. Restrained joints shall be provided on all pipe joints as specified herein and shown on the Drawings. Restrained joints shall be made up similar to that for push-on joints.
- B. Flanged joints shall be brought to exact alignment and all gaskets and bolts or studs inserted in their proper places. Bolts or studs shall be uniformly tightened around the joints. Where stud bolts are used, the bolts shall be uniformly centered in the connections and equal pressure applied to each nut on the stud. Pipes in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot.
- C. Mechanical joints shall be made up with gaskets, glands and bolts. When a joint is to be made up, the bell or socket and plain end shall be cleaned and washed with a solution of mild soap in water; the gland and gasket shall be slid onto the plain end and the end then entered into the socket until it is fully "home" on the centering ring. The gasket shall then be painted with soapy water and slid into position, followed by the gland. All bolts shall be inserted and made up hand tight and then tightened alternately to bring the gland into position evenly. Excessive tightening of the bolts shall be avoided. All nuts shall be pulled up using a torque wrench which will not permit unequal stresses in the bolts. Torque shall not exceed the recommendations of the manufacturer of the pipe and bolts for the various sizes. Care shall be taken to assure that the pipe remains fully "home" while the joint is being made. Joints shall conform to the applicable AWWA Specifications.
- D. Soldered joints shall have the burrs removed and both the outside of pipe and the inside of fittings shall be thoroughly cleaned by proper tools recommended for that purpose. Flux shall be applied to both pipe and inside of fittings and the pipe placed into fittings and rotated to insure equal distribution of flux. Joints shall be heated and solder applied until it shows uniformly around the end of joints between fitting and pipe. All joints shall be allowed to self-cool to prevent the chilling of solder. Combination flux and solder paste manufactured by a reputable manufacturer is acceptable. Unions required adjacent to valves and equipment.
- E. Welded joints shall be made by competent operators in a first class workmanlike manner, in complete accordance with ANSI B31.1 and AWWA C206. Welding electrodes shall conform to ASTM A233, and welding rod shall conform to ASTM A251. Only skilled welders capable of meeting the qualification tests for the type of welding which they are performing shall be employed. Tests, if so required, shall be made at the expense of the Contractor, if so ordered by the Engineer. Unions shall be required adjacent to valves and equipment.
- F. Dielectric isolation such as flange isolation kits, dielectric unions, or similar, shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			•	•	•	•	•	•	•
Galvanized Steel			•	•	•	•	•	•	•
Aluminum	•	•		•	•	•	•	•	•
Cast Iron	•	•	•				•	•	•
Ductile Iron	•	•	•				•	•	•
Mild Steel/ Carbon Steel	•	•	•				•	•	•
Copper	•	•	•	•	•	•			•
Brass	•	•	•	•	•	•			•
Stainless Steel	•	•	•	•	•	•	•	•	

Notes:

• signifies dielectric isolation is required between the two materials noted.

Consult Engineer for items not listed in table.

Provide flange isolation kits for all flanged connections of dissimilar metals and hardware including connections to equipment.

Contractor shall include all isolation descriptions with piping submittals.

- G. Eccentric reducers shall be installed where air or water pockets would otherwise occur in mains because of a reduction in pipe size.
- H. Joints in polypropylene and polyvinylidene fluoride pipe shall be butt fusion weld. All butt welding shall follow the requirements of ASTM D-2657 and the manufacturer's recommendations.

3.03 FLUSHING AND TESTING

- A. All piping shall be properly flushed and tested unless specifically exempted elsewhere in the Specifications or otherwise approved by the Engineer. Gravity sewer piping shall be flushed and tested as specified in Section 02604 – Utility Structures. All other liquid conveying pipelines shall be flushed and tested with water. The Contractor shall furnish and install all means and apparatus necessary for getting the water into the pipeline for flushing and testing including pumps, compressors, gauges, and meters, any necessary plugs and caps, and any required blow-off piping and fittings, etc., complete with any necessary reaction blocking to prevent pipe movement during the flushing and testing. All pipelines shall be flushed and tested in such lengths or sections as agreed upon among the Owner, Engineer, and Contractor. Test pressures shall be as specified in Section 15390 – Pipe Schedules and shall be measured at the lowest point of the pipe segment

being tested. The Contractor shall give the Owner and Engineer reasonable notice of the time when they intend to test portions of the pipelines. The Engineer reserves the right, within reason, to request flushing and testing of any section or portion of a pipeline.

- B. The Contractor shall provide water for all flushing and testing of liquid conveying pipelines. Raw water or nonpotable water may be used for flushing and testing liquid pipelines not connected to the potable water system. Only potable water shall be used for flushing and testing the potable water system.
- C. At the conclusion of the installation work, the Contractor shall thoroughly clean all new liquid conveying pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, etc., which may have entered the pipe during the construction period. If after this cleaning any obstructions remain, they shall be corrected by the Contractor, at the Contractor's own expense, to the satisfaction of the Engineer. Liquid conveying pipelines shall be flushed at the rate of at least 3 feet per second for a duration suitable to the Engineer or shall be flushed by other methods approved by the Engineer.
- D. During testing the piping shall show no leakage. Any leaks or defective piping disclosed by the leakage test shall be repaired or replaced by the Contractor, at the Contractor's own expense, and the test repeated until all such piping shows tight.
- E. After flushing, all liquid conveying pipelines shall be hydrostatically tested at the test pressure specified in the appropriate Piping System Schedule in Section 15390 – Pipe Schedules. The procedure used for the hydrostatic test shall be in accordance with the requirements of AWWA C600. Each pipeline shall be filled with water for a period of no less than 24 hours and then subjected to the specified test pressure for 2 hours. During this test, exposed piping shall show no leakage. Allowable leakage in buried piping shall be in accordance with AWWA C600.
- F. Any leaks or defective pipe disclosed by the hydrostatic test shall be repaired or replaced by the Contractor, at the Contractor's own expense, and the test repeated until all such piping shows tight.

3.04 PAINTING AND COLOR-CODING SYSTEM

- A. All exposed piping specified shall be color coded in accordance with the Owner's standard color designation system for pipe recognition. In the absence of a standard color designation system, the Engineer will establish a standard color designation for each piping service category from color charts submitted by the Contractor in compliance with Section 09900 – Painting.
- B. All piping specified in this Section shall be painted in accordance with Section 09900 – Painting, except as follows:
 - 1. Stainless steel pipe. Flanges and supports or hangers shall be painted.

- END OF SECTION -

SECTION 150003
BASIC HVAC MATERIALS AND METHODS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

1. Adjust list below to suit Project.
2. Piping materials and installation instructions common to most piping systems.
3. Transition fittings.
4. Dielectric fittings.
5. Mechanical sleeve seals.
6. Sleeves.
7. Escutcheons.
8. Grout.
9. Mechanical demolition.
10. Equipment installation requirements common to equipment sections.
11. Painting and finishing.
12. Concrete bases.
13. Supports and anchorages.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For the following:
 - 1. Transition fittings.
 - 2. Dielectric fittings.
 - 3. Mechanical sleeve seals.
 - 4. Escutcheons.

- B. Welding certificates.

1.05 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.07 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products.
- B. Edit this Article with other Part 2 articles in which manufacturers and products, or manufacturers only, are named. See Division 1 Section "Product Requirements" for an explanation of the terms "Available Manufacturers" and "Manufacturers" and the effect these terms have on "Comparable Product" and "Product Substitution" requirements.

- C. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.03 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
3. PVC to ABS Piping Transition: ASTM D 3138.

2.04 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

- a. Cascade Waterworks Mfg. Co.
- b. Dresser Industries, Inc.; DMD Div.
- c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
- d. JCM Industries.
- e. Smith-Blair, Inc.
- f. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.

3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.

4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

- a. Eslon Thermoplastics.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

- a. Thompson Plastics, Inc.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
 - 1. Manufacturers:
 - a. NIBCO INC.
 - b. NIBCO, Inc.; Chemtrol Div.
- E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Fernco, Inc.
 - c. Mission Rubber Company.
 - d. Plastic Oddities, Inc.

2.05 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Eclipse, Inc.
 - d. Epco Sales, Inc.
 - e. Hart Industries, International, Inc.
 - f. Watts Industries, Inc.; Water Products Div.

- g. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
 - 1. Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corp.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
 - 1. Manufacturers:
 - a. Perfection Corp.

- b. Precision Plumbing Products, Inc.
- c. Sioux Chief Manufacturing Co., Inc.
- d. Victaulic Co. of America.

2.06 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Plastic. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.07 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.

- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.08 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Rough brass.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- E. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.09 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 – EXECUTION

3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
 - g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 - h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.
- N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Refer to Division 7 Section "Firestopping" for materials and installation.
- Q. Verify final equipment locations for roughing-in.
- R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.02 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.03 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.04 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.05 PAINTING

- A. Painting of mechanical systems, equipment, and components is specified in Division 9.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.06 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.08 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.09 GROUTING

- A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 15003

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SECTION 15004
COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Mechanical equipment coordination and installation.
 - 2. Common mechanical installation requirements.
 - 3. Commissioning requirements.

1.03 GENERAL REQUIREMENTS

- A. Carefully examine General Conditions, other specification sections, and other drawings (in addition to DIVISION 23), in order to be fully acquainted with their effect on mechanical work. Additions to the contract cost will not be allowed due to failure to inspect existing conditions.
- B. Do all work in compliance with 2017 6th Edition Florida Building Code, and the Codes adopted therein, and 2017 6th Edition Florida Fire Prevention Code. Obtain and pay for any and all required permits, inspections, certificates of inspections and approval, and the like, and deliver such certificates to the Architect/Engineer.
- C. Cooperate and coordinate with all other trades. Perform work in such manner and at such times as not to delay work of other trades. Complete all work as soon as the condition of the structure and installations of equipment will permit. Patch, in a satisfactory manner and by the proper craft, any work damaged by mechanical workmen.
- D. Furnish, perform, or otherwise provide all labor (including, but not limited to, all planning, purchasing, transporting, rigging, hoisting, storing, installing, testing, chasing, channeling, cutting, trenching, excavating and backfilling), coordination, field verification, equipment installation, support, and safety, supplies, and materials necessary for the correct installation of complete and functional mechanical systems (as described or implied by these specifications and the applicable drawings).

1.04 DRAWINGS:

- A. Indicate only diagrammatically the extent, general character, and approximate location of work. Where work is indicated, but with minor details omitted, furnish and install it complete and so as to perform its intended functions.
- B. DIVISION 23 work called for under any section of the project specifications, shall be considered as included in this work unless specifically excluded by inclusion in some other branch of the work. This shall include roughing-in for connections and equipment as called for or inferred. This shall include connection and ductwork required for all fans, hoods, dryers, diffusers etc as required for a functional installation, whether shown on the drawings or not. Check all drawings and specifications for the project and shall be responsible for the installation of all DIVISION 23 work.
- C. Take finish dimensions at the job site in preference to scaled dimensions. Do not scale drawings where specific details and dimensions for DIVISION 23 work are not shown on the drawings, take measurements and make layouts as required for the proper installation of the work and coordination with all drawings and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications that have not been clarified by addendum prior to bidding, it shall be assumed by the signing of the contract that the higher cost (if any difference in costs) is included in the contract price, and perform the work in accordance with the drawings or with the specifications, as determined and approved by the Architect/ Engineer, and no additional costs shall be allowed to the base contract price.
- D. Carefully check the drawings and specifications of all trades and divisions before installing any of the work. Contractor shall in all cases consider the work of all other trades, and shall coordinate his work with them so that the best arrangements of all equipment, piping, conduit, ducts, rough-in, etc., can be obtained. The avoidance of any beams, joist or bracing that is an obstruction to ductwork, shall be included in the bid. This includes the reroute of ductwork or dimension revisions required to obtain the intended function of the ductwork. Bring all obstructions to the attention of the A/E during the shop drawing preparation and prior to fabrication of any ductwork. No cost will be paid by the owner for these modifications that can be identified by reviewing all sets of drawings prior to bid.
- E. All equipment and controllers shall have a minimum fault current withstand rating equal to the overcurrent protective device from which it is fed.
- F. All equipment attached to the exterior of the building structure shall carry the Florida Product Approval rating to withstand hurricane force winds in local area. If no product approval rating is standard, the contractor shall get the new approval or have the structural integrity certified by a Florida Registered Structural Engineer to comply with the requirements at no additional cost to the Owner.
- G. Provide appropriately rated fire dampers or fire/smoke dampers as required by code at penetrations of fire rated or smoke rated walls by all duct work including but not limited

to air supply, return, exhaust and ventilation ducts. These shall be provided at no additional cost whether shown on the drawings or not.

- H. Carefully examine the route for installation and delivery of all equipment. Contractor shall disassemble and reassemble all items required to deliver and install each piece of equipment or provide for the removal and reinstallation of the impeding item. Provide all field support from manufacturer if required to maintain UL listing, warranty or other manufacturer requirements for the installation of the equipment. Notify the AE prior to bid if there are any issues with this requirement being met.
- I. Provide condensate drain lines for all AHU's and FCU's whether shown on drawings or not. Take condensate to the nearest hub drain, floor drain, or exterior dry well if in a concealed area.
- J. Coordinate mechanical equipment voltage requirements with electrical drawings. Notify the A/E of any discrepancies prior to bid. Make all revisions required to coordinate with no additional cost to the owner.
- K. Obtain manufacturer's data on all equipment, the dimensions of which may affect mechanical work. Use this data to coordinate proper service characteristics, entry locations, etc., and to ensure minimum clearances are maintained.

1.05 QUALIFICATIONS OF CONTRACTOR:

- A. DIVISION 15 Contractor shall have had experience of at least the same size and scope as this project, on at least two other projects within the last five years in order to be qualified to bid this project.
- B. Contractor performing any part of this scope of work shall be a Florida State Certified Mechanical Contractor (Type CMC)
- C. Provide field superintendent who has had a minimum of four (4) years previous successful experience on projects of comparable size and complexity. Superintendent shall be on the site at all times during construction.

1.06 SITE VISIT/CONDITIONS

- A. Visit the site of this contract and thoroughly familiarize with all existing field conditions and the proposed work as described or implied by the contract documents. During the course of his site visit, verify every aspect of the proposed work and the existing field conditions in the areas of construction which might affect his work. No compensation or reimbursement for additional expenses incurred due to failure or neglect to make a thorough investigation of the contract documents and the existing site conditions will be permitted.
- B. Install all equipment so that all Code-required and Manufacturer-recommended servicing clearances are maintained. Coordinate the proper arrangement and installation of all

equipment within any designated space. If it is determined that a departure from the Contract Documents is necessary, submit to the A/E, for approval, detailed drawings of the proposed changes with written reasons for the changes. No changes shall be implemented without the approval of the engineer.

- C. Submission of a proposal will be construed as evidence that such examination has been made and later claims for labor, equipment or materials required because of difficulties encountered will not be recognized.
- D. Existing conditions and utilities indicated are taken from existing construction documents, surveys, and field investigations. Unforeseen conditions probably exist, and existing conditions shown on drawings may differ from the actual existing installation with the result being that new work may not be field located exactly as shown on the drawings. Field verify dimensions of all site conditions prior to bidding and include any deviations in the contract. Notify A/E if deviations are found.
- E. All existing mechanical is not shown. Become familiar with all existing conditions prior to bidding and include in the bid the removal of all mechanical equipment, duct, controls wiring, control devices, and control conduits, etc. that is not being reused, back to its originating point.
- F. Locate all existing utilities and protect them from damage. Pay for repair or replacement of utilities or other property damaged by operations in conjunction with the completion of this work.
- G. Work is in connection with existing buildings which must remain in operation while work is being performed. Work shall be in accord with the schedule required by the Contract. Schedule work for a minimum shut down to Owner. Notify Owner 72 hours in advance of any shut-down of existing systems. Perform work during non-operating hours unless otherwise accepted by Owner. Protect existing buildings and equipment during construction.

PART 2 – PRODUCTS

2.01 NOT USED

PART 3 – EXECUTION

- A. COMMON REQUIREMENTS FOR MECHANICAL INSTALLATION
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both mechanical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.
- F. All work shall be executed in a workmanship manner and shall present a neat mechanical appearance upon completion.
- G. Care shall be exercised that all items are plumb, straight, level.
- H. Care shall be exercised so that Code clearance is allowed for all panels, controls. etc., requiring it. Do not allow other trades to infringe on this clearance.
- I. The electrical circuits, components and controls for all equipment are selected and sized based on the equipment specified. If substitutions are proposed, furnish all materials and data required to prove equivalence. No additional charges shall be allowed if additional materials, labor, connections or equipment are needed for substituted products. Any modifications to the electrical design and installation or other trades will also need to be made at no additional cost to the Owner to accommodate the proposed substitutions. Comply with division 1 "substitutions" if allowable.
- J. HVAC environmental control of the project area shall be the responsibility of the contractor for the duration of the work. Where the work area affects other parts of the facility, the contractor shall be responsible for coordinating to maintain environmental services to the other parts of the facility.
- K. The work shall not be considered substantially complete until HVAC system controls are complete, functioning, and tested, and HVAC system testing and balancing are complete.

3.02 CONCRETE PADS

- A. Furnish and install reinforced concrete housekeeping pads for all ground mounted AHU's, Pumps, Condensers, ice tanks, chillers, cooling towers and other free-standing equipment. Unless otherwise noted, pads shall be four (4) inches high and shall exceed dimensions of equipment being set on them, including future sections, by three (3) inches each side, except when equipment is flush against a wall where the side against the wall shall be flush with the equipment.

3.03 DEMOLITION

- A. Unless otherwise specified, all equipment and materials shall remain the property of the Owner. Owner shall have first rights to all demolished items if they decide it is usable. This selected property of Owner shall be delivered to a location where directed by Owner.

er within 15 miles of site and all other items shall be removed from the job site and legally disposed of by the Contractor.

- B. Seal all penetrations through walls left vacant due to the removal of mechanical equipment, piping, and ductwork.

END OF SECTION 15004

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SECTION 15006

DUCTILE IRON PIPE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 09900 – Painting.
- B. Reference Section 15000 – Basic Mechanical Requirements
- C. Reference Section 15390 – Pipe Schedules, for pressure rating requirements for specific applications.

1.02 SUBMITTALS

- A. Submittals shall be provided in accordance with Section 01300 – Submittals.
- B. The Contractor shall submit a certificate from the Manufacturer stating that all linings have been provided in accordance with the specification requirements herein.

PART 2 – PRODUCT

2.01 DUCTILE IRON PIPE AND FITTINGS

- A. All ductile iron pipe and specials shall be marked with the manufacturer's name or trademark, size, weight, thickness class, the date of manufacture, and the word "Ductile".
- B. Ductile iron pipe of the sizes shown or specified shall conform to AWWA C151/ANSI A2 1.51, Grade 60-42-10 for ductile iron pipe centrifugally cast in metal molds or sand-lined molds.
- C. Ductile iron pipe shall conform to AWWA C150/A21.50 for thickness design and shall be supplied in 18-foot or 20-foot nominal lengths or as required to meet the requirements of the Drawings.
- D. Fittings and specials shall be cast iron or ductile iron and conform to the requirements of AWWA C110/A21.10 and AWWA C153/A21.53.
- E. Minimum Class 53 pipe shall be used for flanged spools.

2.02 PIPE COATINGS AND LININGS

- A. All ductile iron pipe and fittings shall have a protective interior lining.

- B. Epoxy-lined ductile iron pipe shall be furnished and installed where specified in Section 15390 – Pipe Schedules.
- C. The lining shall be a ceramic epoxy material such as SP2000 or Protecto 401.
- D. The finished lining shall have a minimum dry film thickness of 40 mils, except at the gasket groove and spigot end up to six inches back from the end of the spigot which shall be 6 mils dry film thickness, minimum.
- E. Lining application shall be performed in strict accordance with the manufacturer's instructions by an applicator approved by the coating manufacturer and under controlled conditions at the applicator's shop or the pipe manufacturer's plant.

2.03 PIPE JOINTS

- A. Requirements for various types of joints are described in the following paragraphs. Unless otherwise noted herein or on the drawings, all exposed ductile iron piping shall have flanged joints.
- B. Flanged Joints
 - 1. Flanged joints and fittings shall have a minimum pressure rating of 250 psi with 125 lb. American Standard flanges.
 - 2. Flanged joints shall conform to ANSI A21.10 and A21.15 (AWWA C 110 and C115), Class 125 with 1/8-inch full faced rubber gaskets.
 - 3. All flanges and fittings shall conform to the requirements of ASME B16.1.
 - 4. Flanges shall be ductile iron and shall be of the threaded or screw on type.
 - 5. The face of the flanges shall be machined after installation of the flange to the pipe. No raised surface shall be allowed on flanges.
 - 6. Flanged pipe shall conform to the requirements of AWWA C115/A21.15.
 - 7. Pipe lengths shall be fabricated to meet the requirements of the Drawings.
 - 8. Gaskets shall be Toruseal by American Cast Iron Pipe Company, Flange-Tyte by US Pipe, or equal. Gaskets shall be full-face, 1/8-inch minimum thickness cloth inserted rubber, red rubber, neoprene, or superior elastomer and shall be compatible with the fluid being conveyed. Gaskets shall have an allowable maximum working pressure and temperature equal to or greater than the service in which it is installed.
 - 9. Bolts shall be of the size and length called for and in accordance with the "American Standard" and comply with the requirements of the ANSI/AWWA Standards. Bolts used for exposed flanged joints shall be a minimum ASTM A307, Grade B carbon

steel, and be in accordance with AWWA C110/A21.10. Bolts used for flanged joints in submerged applications shall be Type 316 stainless steel and installed with dielectric isolation flange kits and anti-seize. All bolts shall have hexagonal heads and nuts of the same material as the bolt. No washers shall be used.

C. Bell and Spigot Joints

1. Bell and spigot pipe shall be provided with push on, Oring rubber gasket, compression type joints and shall conform to the requirements of AWWA C111/A21.11. Fittings and specials shall be supplied with mechanical joints as specified for mechanical joint pipe. If required by installation conditions, pipe shall have caston lugs for adequately tying it together.

D. Mechanical Joints

1. Mechanical joints and fittings shall conform to the requirements of AWWA C111/A21.11. Joints shall be made employing a tapered rubber gasket forced into a tapered groove with a ductile iron follower ring. If required by installation conditions, pipe and fittings shall have caston lugs for adequately tying the pipe and fittings together. These shall be in conformance with standard practice and as outlined under the appropriate AWWA Specifications.
2. Bolts for mechanical joints shall be high-strength low-alloy steel tee-head bolts with hexagonal nuts per AWWA C111/A21.11.
3. Mechanical coupling joint pipe and fittings shall be split type, shouldered end. Coupling materials shall be malleable iron. Couplings shall have a minimum pressure rating and service equal to that of the connected piping.
4. Gaskets shall be of rubber.
5. After installation, buried couplings shall receive two heavy coats of coal tar epoxy (min. 24 mil thickness) which is compatible with the finish of the couplings.
6. Couplings shall be as manufactured by Victaulic Company of America Style 31, or equal.

E. Restrained Joints

1. Restrained joint pipe shall consist of factory manufactured bolted retainer rings, ductile iron locking segments held in place by rubber retainers, or ductile iron retaining rings that lock over the bell of the joint and are secured to prevent rotation, and factory welded retainer beads or rings on the spigot of the pipe. All components of the bolted or snap ring assemblies shall be constructed of corrosion-resistant, high strength, low-alloy steel.
2. Restrained joint pipe shall be Flex-Ring or Lock-Ring type joints as manufactured by American Cast Iron Pipe Company, HP LOK or TR Flex as manufactured by US

Pipe, Bolt-Lok or Snap-Lok as manufactured by Griffin Pipe Products, TR Flex or Super Lock as manufactured by Clow Water Systems Co., or approved equal.

3. The manufactured systems for thrust restraint indicated above shall be used where restrained joint ductile iron pipe and fittings are specified or indicated on the drawings. Gripping gaskets are not an acceptable form of restraint. Thrust restraint and harnessing systems such as threaded-rods, friction clamps, retainer glands shall be used only where specifically specified herein, indicated on the drawings or if allowed by the Engineer in isolated applications where conditions warrant and necessitate their use. Concrete thrust blocks may be used in accordance with the schedule indicated on the drawings, if applicable.

2.04 OUTLETS

- A. Taps should be provided factory welded as flanges or bosses on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, the Contractor shall not use taps and shall refer to Section 15000 – Basic Mechanical Requirements for requirements.

PART 3 – EXECUTION (NOT USED)

- END OF SECTION -

SECTION 15020

PIPE SUPPORTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all equipment, labor, materials, and design calculations required to provide pipe supports in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 3 – Concrete
- B. Section 05050 – Metal Fastening
- C. Section 05010 – Metal Materials
- D. Section 05061 – Stainless Steel
- E. Section 05500 – Metal Fabrications
- F. Section 15000 – Basic Mechanical Requirements

1.03 SUBMITTALS

- A. Pipe support submittals will not be reviewed prior to review and acceptance of pipe layout submittal. Pipe support submittal shall be fully coordinated with approved pipe layout submittal. Contractor shall use approved piping layout submittal drawings to show proposed pipe support type and location with accurate dimensions to demonstrate that supports meet all specified requirements.
- B. Applicable and associated cut sheets and drawings for materials and support components shall be submitted with the Shop Drawings in accordance with or in addition to the submittal requirements specified in Section 01300 – Submittals, Section 15000– Basic Mechanical Requirements and other referenced Sections above.
 - 1. Catalog cut information on all system components such as pipe supports, hangers, guides, anchors, and channel-type supports.
 - 2. Drawings of the piping support systems, locating each support, brace, hanger, guide, component and anchor. Identify support, hanger, guide and anchor type by catalog number and Shop Drawing detail number.
 - 3. With each piping support system Shop Drawing, the Contractor shall attach calculations prepared and sealed by a Professional Engineer, licensed in the State of Florida, showing that the piping support system complies with the specified

requirements, including all building code requirements pertaining to support of piping and other non-structural components.

PART 2 – PRODUCTS

2.01 GENERAL

- A. The Contractor shall be responsible for the design of all piping support systems unless noted otherwise herein. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility of providing a pipe support design sealed by a Professional Engineer, licensed in the State of Florida. Standard details for pipe supports have been included on the Drawings to define minimum requirements as to the types of Contractor designed pipe supports that will be acceptable.
- B. Where a specific location or type of support is shown on the Drawings, the location and type shall be incorporated in the Contractor's pipe support design.
- C. Where special pipe support fabrications are required, products and execution shall be as specified in Section 05500 – Metal Fabrications and other related and referenced Sections of the Specifications.
- D. Existing piping support systems to support new piping shall only be used if the Contractor can show and demonstrate by submitting supporting calculations that they are adequate for the additional load imposed by the new piping, or if they are strengthened to support the additional load.
- E. Contractor's pipe support design should include, but not be limited to, the following criteria and loads imposed on the piping system:
 - 1. Thrust Loads based on the design pressures as specified in Section 15390 – Pipe Schedules. Pipe support design shall not utilize process equipment for thrust restraint or support of piping loads.
 - 2. Dead loads and live loads per the latest version of ASCE/SEI 7 or the local building code if more stringent. Loads shall include, but not be limited to, the following:
 - a. Weight of pipe
 - b. Weight of pipe contents
 - c. Weight of insulation
 - d. Ice loads (If applicable by location, ice loads per code shall be applied as indicated in the governing building code)
 - e. Wind loads

3. Loads associated with thermal expansion and contraction of the piping system over the full range of potential temperatures the piping system could experience that should include, but not be limited to, the following:
 - a. Ambient temperature range per local historical weather data (historic high and low obtained from NOAA)
 - b. Process operating temperature range
 - c. Exposure to sunlight where applicable
4. Additional pipe support design considerations shall include the following:
 - a. A minimum safety factor of 2 or as approved by the Engineer, based upon the yield strength of the support material, shall be used for pipe supports, braces, hangers, and guides as well as for beam and column members used in channel-type support systems.
 - b. The horizontal pipe hanger and/or floor support spacing shall be as recommended by the pipe and/or hanger manufacturer but shall not exceed 10 feet on center unless indicated otherwise herein or on the Drawings.
 - c. The design, sizing and spacing of anchor bolts, including concrete anchors, shall be based on withstanding shear and pullout loads imposed by loading at each particular support. The minimum anchor bolt size shall be ½ inches in diameter. Refer to Section 05050 – Metal Fastening.

2.02 HANGERS AND SUPPORTS

- A. All piping shall be adequately supported and braced by means of stainless steel hangers and/or supports, concrete piers, supplemental lateral bracing components, pre-fabricated brackets, or otherwise as may be required by the location and forces applied per governing code, including gravity and lateral forces from earthquake and/or wind (if outdoors). Generally, concrete supports shall be used where pipe centerline is less than 3 feet above floor, and hangers above 6 feet unless specified or shown otherwise. Supports shall be not more than 10 feet on center for steel and cast iron, 5 feet on center for plastic unless otherwise shown on the Drawings or required by the specific manufacturer. All necessary inserts or appurtenances shall be furnished and installed in the concrete or structures for adequately securing hangers and supports to the structure. Refer to Standard Detail Drawings.
 1. Metal pipe support materials, where stainless steel pipe is supported, shall be Type 304L stainless steel meeting the requirements of Section 05061– Stainless Steel.
 2. Metal pipe supports indicated as standard type pipe hangers are designed and detailed for gravity loading only. Resulting lateral loads from wind, earthquake, or other lateral loads per code, or special loading conditions during construction, shall

be applied to the pipe in accordance with the governing building code. Supplemental lateral stiffening members (when necessary) shall be provided along pipe or at gravity supports using appropriate supplemental members and connections when required by calculations. The Contractor shall include design calculations and details with all pipe hanger and support submissions for review by the Engineer. The main structure and structural components that will support the pipe hangers and other appurtenant components of the facility have been designed to resist all resulting secondary lateral loading from pipe hangers and other non-structural members for gravity and resulting lateral loads.

B. Hangers and supports shall conform to the following requirements:

1. All fabricated metal hangers and supports shall be capable of adjustment after installation. Different types of hangers and supports along a pipe length, including bends, shall be kept to a minimum.
2. Hanger rods shall be straight and vertical. Chain, wire, strap, or perforated bar hangers shall not be used. Hangers shall not be suspended from other piping.
3. Vertical piping shall be properly supported at each floor and between floors by stays or braces to prevent rattling and vibration.
4. Hanger and supports shall prevent contact between dissimilar metals by use of copper plated, rubber, vinyl coated or stainless-steel hangers.
5. Ferrous pipes to be painted shall be painted in accordance with Section 09900 – Painting. Ferrous pipes that require painting or galvanizing shall be supported by galvanized hangers and supports. Stainless steel piping shall be supported by stainless steel saddles and straps (if required).
6. Plastic piping shall be supported by plastic coated steel hangers and supports.
7. Hangers and supports shall provide for thermal expansion throughout the full operating temperature range.
8. Expansion and adhesive type anchors used for pipe hangers and supports shall be Type 316 stainless steel.

C. Metallic hangers and supports may be standard make by Anvil International, Inc., "Witch" by Carpenter & Paterson, Ltd., B-Line Systems, Inc., or equal; and data on the types and sizes to be used shall be furnished to the Engineer for approval. Metallic support system brackets, rods, support clips, clevis hangers, hardware, etc. shall be cast iron or welded stainless steel construction. All gravity type hangers and supports shall be restrained laterally to resist seismic loading and other loading as required by the governing code.

D. Non-metallic support system shall be a heavy-duty channel framing system. Channel frames shall be manufactured by the pultrusion process using corrosion grade polyester

or vinylester resins. All fiberglass construction shall include suitable ultraviolet inhibitors for UV exposure and shall have a flame spread rating of 25 or less per ASTM E84. Piping accessories, pipe clamps, clevis hangers, support posts, support racks, fasteners, etc., shall be constructed of vinylester or polyurethane resin. Non-metallic support systems shall be standard make Aickinstrut by Aickinstrut, Inc., Unistrut Fiberglass by Unistrut, Inc., Enduro Fiberglass Systems, or equal. The Contractor shall submit data on the types and sizes of approval. Unless otherwise shown or specified the Contractor shall provide support spacings in the conformance with the pipe and support system manufacturer's requirements.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Support piping connections to equipment by pipe support and not by the equipment.
- B. Support large or heavy valves, fittings, flow meters and appurtenances independently of the connected piping.
- C. Support no pipe from the pipe above it.
- D. Support piping at changes in direction or in elevation, adjacent to flexible joints, expansion joints, and couplings, and where shown.
- E. The Contractor shall not install piping supports and hangers in equipment access areas or bridge crane runs.
- F. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.
- G. Install pipe anchors (fixed supports and/or guides) where shown and/or as may otherwise be required to withstand expansion thrust loads and to direct and control thermal expansion. The Contractor may install additional pipe anchors and flexible couplings to facilitate piping installation, provided that complete details describing location, pipe supports and hydraulic thrust protection are submitted.

- END OF SECTION -