



CONTRACT DOCUMENTS FOR THE
CONSTRUCTION OF

DURHAM DIGESTER GAS CONVEYANCE SYSTEM MODIFICATIONS

Bid Set
Technical Specifications
Project No. 6919

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**DURHAM DIGESTER GAS CONVEYANCE SYSTEM MODIFICATIONS
PROJECT NO. 6919**

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DURHAM DIGESTER GAS CONVEYANCE SYSTEM MODIFICATIONS
PROJECT NO. 6919

PROFESSIONAL OF RECORD CERTIFICATION(s):

Signing as the Professional of Record
for the sections listed below:

Divisions: 11 and 15



EXPIRES: 12/31/2019



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PROJECT NO. 6919

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Division: 16 and 17



EXPIRES: 12/31/2020

DIVISION 11 EQUIPMENT

11556 Digester Gas Safety Equipment and Specialties

SECTION 11556

DIGESTER GAS SAFETY EQUIPMENT AND SPECIALTIES

PART 1 GENERAL**1.01 DESCRIPTION****A. SCOPE:**

1. This section specifies gas handling equipment for the digester gas conveyance and utilization system.

Item
Flame Arrestor Assembly with Thermal Shut-Off Valve

1.02 QUALITY ASSURANCE**A. REFERENCE STANDARDS:**

1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
API 520	Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries
API 2000	Venting Atmospheric and Low-pressure Storage Tanks
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
NFPA 820	Standards for Fire Protection in Wastewater Treatment and Collection Facilities
UL	Underwriters Laboratories, Inc.

1.03 SUBMITTALS**A. The following submittals shall be provided as specified in Section 01330:**

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked (✓) to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner's Representative shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with

the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Manufacturer's catalog and/or other data confirming conformance to specified design, material and equipment requirements.
3. Predicted and/or certified performance data and/or curves as applicable developed for the specific application (digester gas), confirming conformance to specified design and operating requirements and characteristics for all equipment.
4. Installation requirements, showing clearance required for maintenance purposes.

1.04 ENVIRONMENTAL CONDITIONS

- A. The equipment specified in this section shall be suitable for installation and operation outdoors at an elevation of 400 feet above sea level. It shall be located in a hazardous area having a NEC Class I, Division 1, Group D classification. Equipment mounted in exposed locations will be subjected to ambient temperatures expected to range between -10 degrees F and 108 degrees F, and relative humidity ranging between 10 and 95 percent. Equipment specified in this section shall be installed as shown and some parts will be in contact with anaerobic sewage sludge gas. Temperatures inside the digesters will range between 95 degrees F and 100 degrees F.
- B. The digester gas is expected to contain fine particulate matter, moisture, greasy oils, carbon dioxide, and small quantities of hydrogen sulfide and nitrogen gases. Carbon dioxide concentration may be expected to range between 30 and 50 percent by weight, with the remainder comprised primarily of methane. The digester gas is expected to have an average specific gravity of approximately 0.86 and a net heating value of about 500 to 600 Btu per standard cubic foot.

1.05 DESIGN REQUIREMENTS

- A. The flame arrester assembly shall be designed and shall perform in accordance with the following:

Requirement	Value
Connection size, inches	12

- B. All equipment specified in this section shall comply with the latest version of the NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The DISTRICT and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of the Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that a named manufacturer's standard equipment or products will comply with the requirement of this Section. For purposes of standardization, manufacturer shall be Varec Biogas.

2.02 MATERIALS

A. MATERIALS OF CONSTRUCTION:

Component	Material
Flame Arrester Housing	Low copper cast aluminum
Flame Bank Assembly	Stainless steel ASTM A276, Type 316
Flame Bank Sheets	Stainless steel ASTM A276, Type 316

2.03 FLAME ARRESTOR ASSEMBLY

- A. The flame trap assembly shall be configured horizontally where shown on the drawings.
- B. The flame arrester net free area through the bank assembly shall not be less than three times the corresponding size standard pipe. The entire bank assembly shall slide easily out of the arrester housing to facilitate inspection and cleaning. Removing or replacing the assembly shall not require support for alignment, require a jackscrew for extending the housing, or place strain on the connecting piping. The bank frame shall be extensible and shall be filled with corrugated rectangular-shaped bank sheets constructed of type 316 stainless steel. Flame arresters shall be self-draining. The flame arresters shall include a concentric housing. The arrester housing shall be low copper cast aluminum. The bank assembly shall include a low copper aluminum frame and 316 stainless steel bank sheets. Sheets shall be removable without the use of jacking bolts.
- C. The flame arrestor shall have a 1-inch drain connection.
- D. The flame arrester assembly shall be interconnected with a thermal shut-off valve. The valve shall be the spring-actuated pallet closure type. The thermal valve shall operate within 15 seconds when the thermal element reaches 260 degrees F and melts, causing the pallet to be forced closed by the spring. The fusible element shall be replaceable without disassembling the valve. The thermal valve assembly shall be constructed of low copper aluminum with stainless steel internals and with Buna-N O-rings. The assembly shall be leak proof to 5 psig (34.5 kPa).
- E. Thermal shut-off valve and flame arrestor flanges shall be drilled to ANSI 150 (ASA 125) FF flanged dimensions. All hardware shall be type 316 stainless steel.

PART 3 EXECUTION

3.01 SPARE PARTS

- A. The following spare parts shall be provided:
 - 1. One set of extensible bank assembly for flame arrester.

3.02 PRODUCT DATA

- A. The following information shall be provided for each item in accordance with Section 01330:
 - a. Applicable operation and maintenance information as specified in Section 01782.

3.03 MANUFACTURER'S SERVICES

A. ON-SITE INSPECTIONS:

1. Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
 - a. Installation Inspections: Assist, supervise, and inspect the Contractor's activities during installation. Provide 4 hours of installation inspection during installation.

PART 4 INSTALLATION

- A. All gas handling equipment shall be installed as shown on the contract drawings and in strict accordance with the equipment manufacturer's recommendations.

END OF SECTION

DIVISION 15 MECHANICAL

15050 Piping Systems

15061 Steel Pipe

15067 Stainless Steel Piping

15075 Joint Gaskets

15085 Piping Connections

15103 Butterfly Valves

15147 Solenoid Valves

SECTION 15050 PIPING SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:

1. This section specifies systems of process piping and general requirements for piping systems. Detailed specifications for the components listed on the Piping System Specification Sheets (PIPESPEC) are found in other sections of Division 15. This section shall be used in conjunction with those sections.

B. DEFINITIONS:

1. Pressure terms used in Section 15050 and elsewhere in Division 15 are defined as follows:
 - a. Maximum: The greatest continuous pressure at which the piping system operates.
 - b. Test: The hydrostatic pressure used to determine system acceptance.

1.02 QUALITY ASSURANCE

A. REFERENCES:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AASHTO M36/M36M	Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains
ANSI A13.1	Scheme for the Identification of Piping Systems
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800
ANSI B16.3	Malleable Iron Threaded Fittings Class 150 and 300
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket Welding and Threaded
ANSI B16.12	Cast Iron Threaded Drainage Fittings

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Reference	Title
ANSI B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ANSI B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes
ANSI B31.1	Power Piping
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Qualifications
ASTM A47	Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded and Seamless
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A312/A312M	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C296	Asbestos-Cement Pressure Pipe
ASTM C443-REV A	Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2513	Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2996	Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D3034	Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3261	Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D4174	Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
AWWA C105	Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA M11	Steel Pipe—A Guide for Design and Installation
CISPI 301	Specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings
FEDSPEC L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
MIL-H-13528B	Hydrochloric Acid, Inhibited, Rust Removing
MIL-STD-810C	Environmental Test Methods
SAE J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems
UPC	Uniform Plumbing Code

B. FITTINGS AND COUPLING COMPATIBILITY:

1. To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

1.03 ACTION SUBMITTALS:

1. A copy of this specification section and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

PART 2 PRODUCTS**2.01 PIPING MATERIALS**

- A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed on the piping system specification sheets. Piping materials shall conform to detailed specifications for each type of pipe and piping appurtenance specified in other sections of Division 15.
- B. PE PIPE
 1. PE pipe shall meet the requirements of ASTM D1248, Type III, Grade P 34, Class C, 100 psi or as specified in the PIPESPEC at the end of this Section, whichever is higher. Fittings shall be of the same material, molded socket fusion for sizes 4 inch diameter and smaller and molded or fabricated butt fusion for sizes 6 inch and larger. Fittings shall be 125 psi or as specified in the PIPESPEC at the end of this Section, whichever is higher. Heat fusion welding shall be in conformance with ASTM D2657.

2.02 PIPING IDENTIFICATION**A. PLASTIC CODING MARKERS:**

1. Plastic markers for coding pipe shall conform to ANSI A13.1 and shall be as manufactured by W. H. Brady Company, Seton Name Plate Corporation, Marking Services Inc., or equal. Markers shall be the mechanically attached type that are easily removable; they shall not be the adhesive applied type. Markers shall consist of pressure sensitive legends applied to plastic backing which is strapped or otherwise mechanically attached to the pipe. Legend and backing shall be resistant to petroleum based oils and grease and shall meet criteria for humidity, solar

radiation, rain, salt, fog and leakage fungus, as specified by MIL-STD-810C. Markers shall withstand a continuous operating temperature range of -40 °F to 180 °F. Plastic coding markers shall not be the individual letter type but shall be manufactured and applied in one continuous length of plastic.

2. Markers bearing the legends on the background colors specified in the PIPESPEC shall be provided in the following letter heights:

Outside pipe diameter, ^a inches	Letter height, inches
Less than 1-1/2	1/2
1-1/2 through 3	1-1/8
Greater than 3	2-1/4

^a Outside pipe diameter shall include insulation and jacketing.

3. In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

B. PLASTIC TRACER TAPE:

1. Tracer tape shall be 6 inches wide, colored the same as the background colors as specified in Table A, paragraph 15050-3.06, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length and shall be as manufactured by Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or equal.
2. Two messages shall be printed on the tape. The first message shall read **"CAUTION CAUTION CAUTION _____ PIPE BURIED BELOW"** with bold letters approximately 2 inches high. The blank shall be filled with the particular system fluid abbreviations as shown in Table A. The second message shall read **"CALL _____"** with letters approximately 3/4 inch high. Both messages shall be printed at maximum intervals of 2 feet.

2.03 VALVES

- A. Valves of the same size and service shall be provided by a single valve manufacturer. Packing shall be nonasbestos material. Actual length of valves shall be within 1/16 inch (plus or minus) of the manufacturer's specified length. Flanges shall meet the requirement of ANSI B16.5. Push-on and mechanical joints shall meet the requirements of AWWA C111.

2.04 PRODUCT DATA

- A. Product data on piping materials shall be provided in accordance with Section 01330 where specified.
- B. Piping layout drawings shall be transmitted to Owner's Representative a minimum of 2 weeks prior to construction. Drawings shall be original layouts by the Contractor; photocopies of contract drawings are not acceptable.

PART 3 EXECUTION**3.01 INSTALLATION****A. LOCATION:**

1. Piping shall be provided as specified except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction.

B. PIPING SIZES:

1. Where the size of piping is not specified, the Contractor shall provide piping of the sizes required by UPC. Unless specified otherwise, small piping (less than 1 inch in diameter) required for services not described by UPC shall be 1/2 inch.

C. PE Pipe

1. Unless otherwise specified, PE pipe and fittings 4 inch diameter and smaller shall be joined by means of thermal socket fusion and pipe 6 inch and larger by thermal butt fusion. Butt-fusion joining of the pipes and fittings shall be performed with special joining equipment in accordance with procedures recommended by pipe manufacturer. Tensile strength at yield of butt-fusion joints shall not be less than pipe. Flanged adapters shall be provided for connection to valves and where specified.

D. PIPE SUPPORT, ANCHORAGE AND SEISMIC BRACING:**1. GENERAL:**

- a. Piping shall be supported by anchor brackets, guides, saddles or hangers. The contractor shall be responsible for the design of seismic restraints not specifically shown or called out on the drawings. Acceptable types of supports, guides, saddles, hangers and structure attachments for general pipe support, expansion/contraction and for seismic bracing, as well as anchorage details, are shown on the drawings. Minimum spacing shall be as specified for supports and for seismic bracing. Where a specific type of support or anchorage is indicated on the drawings, then only that type shall be used there. Piping shall be vertically supported by anchor brackets, guides, saddles or hangers and shall be seismically braced where indicated to resist lateral load. Supports shall be provided on each run at each change of direction. Pipe supports shall be hot-dip or mechanically galvanized. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.

2. PIPING CONNECTIONS TO MACHINES:

- a. Piping at machine connections shall be aligned in all planes to permit insertion of bolts at bolted connections or coupling screwed connections without using jacks, come-a-longs or other mechanical means to align field piping with the connections at the machines. Bolts shall not be forced into mating flange bolt holes and shall be capable being withdrawn using finger pressure alone. The use of 'dutchmen' mitered sections or similar specials to achieve the required alignment with machine connections is strictly prohibited.

E. ANCHORAGE FOR BURIED PIPING:

1. All plugs, caps, tees and bends in buried pressure piping systems shall be anchored by means of reaction backing or restrained joints as specified.

F. BEDDING AND BACKFILL:

1. Bedding and backfill for buried piping shall be as specified.

G. EQUIPMENT CONNECTION FITTINGS

1. Where shown, equipment connection fittings as specified in Section 15085 shall be provided between field piping systems and equipment inlet and outlet connections.

H. FLEXIBILITY

1. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints as specified in Section 15085.

3.02 PIPING IDENTIFICATION

A. PIPE CODING:

1. After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with plastic markers as specified in paragraph 15050-2.02 A. Legend markers and directional arrows shall be located at each side of walls, floors and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 50-foot centers.

B. PLASTIC TRACER TAPE:

1. A single line of tape as specified in paragraph 15050-2.02 B shall be provided 2.5 feet above the centerline of buried pipe. For pipelines buried 8 feet or greater below finished grade, contractor shall provide a second line of tape 12 inches below finished grade, above and parallel to each buried pipe. Tape shall be spread flat with message side up before backfilling.

3.03 VALVE IDENTIFICATION

- A. Stainless steel tags bearing the specified valve number, and valve name where shown in contract drawings, stamped in 1/4-inch high letters filled with black for contrast shall be installed on valve flanges in a position visible from floor level. Flangeless valves 8 inches in diameter and larger shall have tags attached to the valve body by self-tapping corrosion resistant metal screws. Flangeless valves 6 inches in diameter and smaller shall have tags attached to the valve stem by stainless steel wire. Wire shall be 0.063 inch minimum.

3.04 TESTING

A. GENERAL:

1. Upon completion of piping, but prior to application of insulation on exposed piping, the Contractor shall test the piping systems. Pressures, media and test durations shall be as specified in the PIPESPEC. Equipment which may be damaged by the specified test conditions shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gage's range. Unless otherwise specified, the Contractor shall notify the Owner's Representative 24 hours prior to each test.

Unless otherwise specified, testing, as specified herein, shall include existing piping systems which connect with new pipe systems. Existing pipe shall be tested to the nearest existing valve. Any piping which fails the test shall be repaired. Repair of existing piping will be considered and paid for as extra work.

B. GAS, AIR, AND VAPOR SYSTEMS:

1. The Contractor shall test steam lines hydrostatically in accordance with the ASME procedure for testing pressure piping.
2. Unless otherwise specified, the testing medium for other gas, air and vapor systems shall be as follows:

Pipeline size	Specified test pressure	Testing medium
2 inch and smaller	75 psi or less	Air or water
2 inch and smaller	Greater than 75 psi	Water
Greater than 2 inch	3 psi or less	Air or water
Greater than 2 inch	Greater than 3 psi	Water

3. The allowable leakage rate for hazardous gas systems, insulated systems, and systems tested with water shall be zero at the specified test pressure throughout the specified test period. Hazardous gas systems shall include digester gas and natural gas systems.
4. The allowable leakage rate for other systems tested with air shall be based on a maximum pressure drop of 5 percent of the specified test pressure for the duration of the period. Prior to starting a test interval using air, the air shall be at ambient temperature and specified test pressure.

C. DRAINS:

1. Drain systems, other than pumped drain systems, shall be tested in accordance with UPC.

3.05 CLEANING AND FLUSHING

A. GENERAL:

1. Piping systems shall be cleaned following completion of testing and prior to connection to operating, control, regulating or instrumentation equipment. The Contractor may, at his option, clean and test sections of buried or exposed piping systems. Use of this procedure, however, will not waive the requirement for a full pressure test of the completed system. Unless specified otherwise, piping 24 inches in diameter and smaller shall first be cleaned by pulling a tightly fitting cleaning ball or swab through the system.

B. TEMPORARY SCREENS:

1. Upon completion of the cleaning, the Contractor shall connect the piping systems to related process equipment. Temporary screens, provided with locator tabs which remain visible from the outside when the screens are in place, shall be inserted in pipelines at the suction of pumps and compressors in accordance with the following table:

Equipment suction or piping size, inches	Maximum screen opening, inches
0 - 1	1/16
1-1/4 - 3	1/4
3-1/2 - 6	1/2
Over 6	1

2. The Contractor shall maintain the screens during testing, initial start-up, and initial operating phases of the commissioning process. In special cases, screens may be removed as required for performance tests. The Contractor shall remove the temporary screens and make the final piping connections after the screens have remained clean for at least 24 consecutive hours of operation. Systems handling solids are exempted.

C. GAS AND AIR SYSTEMS:

1. Unless otherwise specified, gas and air system piping 6 inches in diameter and smaller shall be blown out, using air or the testing medium specified. Piping larger than 6 inches shall be cleaned by having a swab or "pig" drawn through the separate reaches of pipe. After connection to the equipment, it shall then be blown out using the equipment. Upon completion of cleaning, the piping shall be drained and dried with an airstream. Sludge gas, natural gas, and propane systems shall be purged with nitrogen and a nitrogen pad maintained at 10 psi until put in service.

3.06 PIPING SPECIFICATION SHEETS (PIPESPEC)

- A. Piping and valves for groupings of similar plant processes or types of service lines are specified on individual piping specification sheets (PIPESPECS). Piping services are grouped according to the chemical and physical properties of the fluid conveyed and/or by the temperature or pressure requirements. Each grouping of services (PIPESPEC) is identified by a piping system number. Piping services specified in the PIPESPECS and on the drawings are alphabetically arranged by designated service symbols as shown in Table A. Table A also indicates the system number, fluid category, and pipe marker background color of each service.

Table A, Piping Services

Symbol	Service	System	Fluid Category	Pipe Marker Background Color
DG	Digester Gas	4A	Gas	Yellow
NG	Natural Gas	5	Gas	Yellow
CDS	Condensate Drain	4A	Gas	Yellow

3.06 PIPING SPECIFICATION SHEETS--PIPESPEC

Piping Symbol/Service: DG-Digester Gas System--4A
CDS- Condensate Drain

Test Requirements:

Medium: Air; ref. spec paragraph 15050-3.04 B.
Pressure: 3 psig
Duration: 120 minutes

Gasket Requirements:

Flange: Compressed neoprene gasketing
Push-on/Mech Cpl: N/A

Exposed Pipe and Valves:

(See drawings for pipe size and valve type)

(3" and smaller)

Pipe: Stainless steel; ASTM A312, Type 316, Schedule 40S. Ref spec Section 15067.

Conn; threaded, ANSI B1.20.1.

Ftgs; ASTM A403, material, ends and wall thickness to match pipe.

Valves: Ball; Jamesbury Fig. 351, Nibco T-580, or equal.

Lift check; Crane 27TF, Lunkenheimer 231, or equal.

(4" and larger)

Pipe: Stainless steel; ASTM A778, Type 316L. Ref. spec Section 15067.

Conn; butt weld or flanged couplings where specified.

Ftgs; ASTM A774, material, ends and wall thickness to match pipe.

Valves: Butterfly; ref. spec Section 15103.

Remarks:

1. Not used.

3.06 PIPING SPECIFICATION SHEETS--PIPESPEC

Piping Symbol/Service: NG--Natural Gas System--5

Test Requirements:

Medium: Ref. spec paragraph 15050-3.04 B.

Pressure: 150 psig

Duration: 120 minutes

Gasket Requirements:

Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder

Push-on/Mech Cpl: N/A

Exposed Pipe and Valves:

(See drawings for pipe size and valve type)

(2" and smaller)

Pipe: Steel; ASTM A106, seamless, Grade B, black, no lining. Ref. spec Section 15061.

Conn; taper threaded, ANSI B1.20.1.

Ftgs; malleable iron, ASTM A197, ANSI B16.3, Class 150; ends to match pipe.

Valves: Ball; Jamesbury Fig. 351, Nibco T-580, or equal.

Buried and Encased Pipe and Valves:

(See drawings for pipe size and valve type. Omit coating on encased pipe.)

(2" and smaller)

Pipe: Polyethylene; ASTM D1248, Type III, Grade 3, Class C, SDR-11. Ref. Provide magnetic tracer tape.

Conn; thermal socket fusion or butt-fusion welded with flanged adapters for valves.

Ftgs; polyethylene, molded; ends and SDR to match pipe.

Valves: N/A

Remarks:

1. Not used.

END OF SECTION

SECTION 15061

STEEL PIPE

PART 1 GENERAL**1.01 DESCRIPTION**

- A. This section specifies steel pipe and fittings.

1.02 QUALITY ASSURANCE**A. REFERENCES:**

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.3	Malleable Iron Threaded Fittings, Class 150 and 300
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket-Welding and Threaded
ASTM A36/A36M	Structural Steel
ASTM A47	Ferritic Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106 REV A	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A283/A283M REV A	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
ASTM A536	Ductile Iron Castings
ASTM A570/A570M	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A572/A572M REV B	High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe--4 In. and Larger-- Shop Applied

Reference	Title
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services--Sizes 4 In. Through 144 In.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA M11	Steel Pipe--A Guide for Design and Installation
SSPC-SP10	Near-White Blast Cleaning

B. TESTING:

1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

- A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, or AWWA C200 as specified in Section 15050, Piping Systems.
- B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.

2.02 PIPE MANUFACTURE

- A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 15050. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified.
- B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24 inch diameter and 1/4 inch for pipe 26 inch diameter and larger. Increased shell thickness shall be provided where specified.

2.03 CONNECTIONS

- A. Connections shall be as specified in Section 15050 and shall conform to Section 15085. Coating for buried connections shall be as specified in paragraph 15085-2.06.

2.04 FITTINGS AND APPURTENANCES

- A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.

- B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208.
- C. Fittings for grooved end piping systems shall be full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.
- D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.05 PIPE COATING

- A. Coat gas piping with Epoxy/Epoxy/Urethane coating system, Sherwin Williams Zinc Clad IV/Macropoxy 646/Hi Solids Polyurethane, Tnemec Series 90-97/Series 66HS/Series 1095, or equal.
 - 1. 3 to 4 mils of zinc rich primer, one intermediate epoxy coat at 5 to 6 mils and one finish coat of polyurethane at 2 to 3 mils DFT.
 - 2. Surface preparation and application in accordance with manufacturers recommendations.
 - 3. Color to match existing gas piping color

2.06 JOINT GASKETS

- A. Joint gaskets shall be as specified in Section 15075.

2.07 PRODUCT DATA

- A. The following information shall be provided in accordance with Section 01330:
 - 1. Affidavits of Compliance with AWWA C200, ASTM A53, or ASTM A106 as applicable.
 - 2. Contractor's layout drawings as specified in paragraph 15050-2.04.

PART 3 EXECUTION

3.01 INSTALLATION

- A. GENERAL:
 - 1. Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206 and Section 15085.
 - 2. Sleeve-type mechanical pipe couplings shall be provided in accordance with AWWA M11 and paragraph 15085-2.02 A.
 - 3. Pipe lining and coatings at field joints shall be applied as specified in paragraphs 15061-2.05 and 2.06.

3.02 TESTING

- A. Hydrostatic testing shall be in accordance with Section 4 of AWWA C600 except that test pressures and allowable leakage shall be as listed in Section 15050.

END OF SECTION

SECTION 15067

STAINLESS STEEL PIPING

PART 1 GENERAL**1.01 DESCRIPTION****A. SCOPE:**

1. This section specifies stainless steel pipe and fittings.

B. TYPES OF SERVICE:

1. Stainless steel piping specified in this section shall be used for piping systems as Specified in Section 15050.

1.02 QUALITY ASSURANCE**A. REFERENCES:**

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, 250, and 800
ANSI B16.11.80	Forged Steel Fittings, Socket Welding and Threaded.
ANSI B31.1	Power Piping
ANSI B36.19M	Stainless Steel Pipe
ASME Section IX (1989)	Boiler and Pressure Vessel Code; Welding and Brazing Qualifications
ASTM A182/A182M	Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A194/A194M	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High-Temperature Service
ASTM A240	Heat-Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A312/A312M	Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A320/A320M	Alloy Steel Bolting Materials for Low-Temperature Service

Reference	Title
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A409/A409M	Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip
ASTM A774/A774M	As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
ASTM A778	Welded, Unannealed Austenitic Stainless Steel Tubular Products

B. QUALIFICATIONS:

1. All shop fabricated stainless steel pipe and fittings shall be furnished by a single manufacturer who is experienced and qualified in the manufacture and fabrication of the items to be furnished. The pipe and fittings shall be shop-fabricated and field-installed in accordance with common industrywide practices and methods and shall comply with these specifications.
2. Only weld procedures which have been qualified under ASME Section IX and only welders who have successfully completed performance qualification tests per ASME Section IX on these qualified procedures shall be utilized.

C. TESTING:

1. Factory testing shall conform to the requirements of ASTM A312, ASTM A409 HT-0, or ASTM A778, depending on the size and type of stainless steel pipe provided.

1.03 SUBMITTALS**A. The following information shall be provided in accordance with Section 01330:**

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked (✓) to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark 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, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner's Representative shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Shop fabrication drawings showing details of materials, piping, fittings, couplings, dielectric connections, joint locations and details, types and locations of supports.
3. Other data necessary to show conformance of the complete piping system to these specifications.

PART 2 PRODUCTS

2.01 PIPE

- A. Unless otherwise specified, stainless steel pipe 2-1/2 inches and smaller shall be Type 316L, seamless, threaded joints conforming to ASTM A312. The minimum wall thickness shall be Schedule 40S.
- B. Unless otherwise specified, stainless steel piping 3 inches and larger shall be manufactured from ASTM A240 annealed and pickled sheets and plates, Type 316L, in accordance with ASTM A778 or ASTM A409 HT-0. Only extra-low carbon (ELC) materials with 0.030 percent maximum carbon shall be used. Pipe shall be manufactured to nominal pipe sizes as listed in ANSI B36.19 and shall have the following nominal wall thickness:

Nominal pipe size, inches	Schedule gage/plate	Wall thickness inches
4	10S	0.126
6	10S	0.134
8	10S	0.148
10	10S	0.165
12	10S	0.180

2.02 FITTINGS

- A. Unless otherwise specified, stainless steel fittings, 2-1/2-inches and smaller, shall be ASTM A403, of the same material and pressure rating as the pipe, threaded long radius with dimensions conforming to ANSI B16.11.
- B. Unless otherwise specified, stainless steel fittings, 3-inch and larger, shall be butt-weld type manufactured in accordance with ASTM A774 of the same material and in the same thicknesses as the pipe. Long radius elbows up to 24 inches in diameter shall be smooth flow. All short radius, special radius, and reducing elbows and long radius elbows greater than 24 inches in diameter shall be of mitered construction. Reducers shall be straight tapered, cone type. Tees, crosses, laterals, and wyes shall be shop-fabricated from pipe.

2.03 JOINTS

- A. Stainless steel pipe fabricated into spool pieces shall have shop-welded circumferential butt-weld joints or flanges. Unless otherwise specified, flanged joints shall be Van Stone joints made up of stainless steel slip-on type rolled-angle face rings and ductile iron backup flanges drilled to ANSI B16.1, Class 125 standard. The angle face ring thickness shall be equal to or greater than the wall of the pipe or fitting to which it is welded, and it shall be continuously welded on both sides to the pipe or fitting. The angle leg shall not interfere with the flange bolt holes. The backup flanges for ductile iron and stainless steel shall be supplied with the following nominal thicknesses.

Nominal pipe size, inches	Flange thickness, inches
3	1/2
4	9/16
6	5/8
8	5/8
10	5/8
12	3/4

2.04 COUPLING

A. GENERAL:

1. Fabricated stainless steel piping shall be shop-prepared for pipe couplings where specified. Unless otherwise specified, couplings shall be arched-band or grooved type.

B. SLEEVE TYPE:

1. Sleeve type couplings, where specified, shall be of standard steel construction as specified in paragraph 15085-2.02 A. Pipe shall be plain-end with external weld beads ground smooth to ensure proper gasket seating. For pressure pipe lines, sleeve coupling joints shall be restrained by the use of harness rods connecting across the joint to flange lugs on adjacent flange joints. Where no adjacent flange joints exist, stainless steel harness lugs shall be welded to the pipe to receive the harness rods.

C. ARCHED-BAND TYPE:

1. Arched-band type couplings shall be stainless steel of the same material and wall thickness as the pipe and shall be Depend-O-Lok type as manufactured by Brico or equal. Couplings shall be Fixed-FxF, Expansion-ExE, or Fixed by Expansion-FxE as specified or as required. The pipe shall be plain-end with external weld beads ground smooth and with S.S. restraining rings shop-welded to the piping for fixed type couplings.

D. GROOVED-END TYPE:

1. Grooved-end or split type couplings shall be malleable iron or ductile iron as specified in paragraph 15085-2.02 C except that submerged couplings shall be the same material as the pipe. The pipe ends shall be roll-grooved to the coupling manufacturer's specifications. Where roll grooving is impractical, the pipe shall have heavy-wall machine-grooved pipe nipples or machined ring collars fully welded to the pipe or fitting. Nipples shall be taper-bored to the I.D. of the adjoining pipe to allow full-weld penetration. Collars shall be welded on both sides to the piping. Nipples and collars shall be of the same alloy as the piping.

E. EXPANSION TYPE:

1. Unless otherwise specified, expansion couplings shall be the flanged rubber arch type as specified in Section 15090. Pipe flanges shall be provided for these couplings.

2.05 THREADED CONNECTIONS

- A. Threaded pipe, gage, or instrument connections shall be made using stainless steel, 150-pound, threaded half-couplings conforming to ASTM A182 or ASTM A276, shop welded to the pipe at the locations specified.

2.06 GASKETS

- A. Unless otherwise specified, gaskets shall be as specified in the PIPESPECS and in paragraph 15085-2.03. For air lines, gaskets shall be neoprene or EPDM suitable for use at temperatures to 240 degrees F.

2.07 BOLTS

- A. Bolts, nuts, and washers for stainless steel flange assemblies and stainless steel couplings shall be the same material, conforming to ASTM A320 for low-temperature service and ASTM A193 and ASTM A194 for high-temperature service. Bolts, nuts and washers for other couplings shall be as specified in referenced paragraphs for the couplings.

2.08 PIPE SUPPORT SYSTEMS

- A. Unless otherwise specified, all hangers, rods, structural attachments, and other components of support systems for stainless steel pipe shall be of the same materials as the pipe.

2.09 FINISH

- A. After all shop operations have been completed, pipe and fittings shall be pickled and passivated in manufacturer's plant, and scrubbed and washed until discoloration and possible iron picked up from manufacturing process are removed. The standard finish for 16-gage through 8-gage material shall be No. 1 or 2B per ASTM A480; 3/16-inch and heavier plate material shall be No. 1 mill finish or better per ASTM A480.

2.10 PRODUCT DATA

- A. The following information and data shall be provided in accordance with Section 01330:
 - 1. Certifications specified in the following documents:
 - a. ASTM A403, paragraph 14.1
 - b. ASTM A774, paragraph 14.1
 - c. ASTM A778, paragraph 14.1
 - d. ASTM A409, paragraph 17.1
 - 2. Test results specified in paragraph 15067-1.02 C.
 - 3. Names and qualification records of proposed welders.

PART 3 EXECUTION**3.01 PIPE CUTTING, THREADING, AND JOINTING**

- A. Pipe cutting, threading, and jointing shall conform to the requirements of ANSI B31.1. All pipe threads shall be lubricated with Teflon tape.

3.02 WELDING**A. GENERAL:**

- 1. Piping with wall thickness up to 11 gage (0.120 inch) shall be welded with the TIG (GTAW) process. Unless otherwise specified, heavier walls shall be properly beveled and have a root pass with the TIG (GTAW) process followed by subsequent passes with the TIG (GTAW), MIG (GMAW), or Metallic Arc (SMAW) process. Filler wire of ELC grades only shall be added to all welds to provide a cross section at the weld equal to or greater than the parent metal. Weld deposit shall be smooth and evenly distributed and have a crown of no more than 1/16 inch on the I.D. and 3/32 inch on the O.D. of the piping. Concavity, undercut, cracks, or crevices shall not be allowed. Butt welds shall have full penetration to the interior surface, and inert gas shielding shall be provided to the interior and exterior of the joint. Excessive weld deposits, slag, spatter, and projections shall be removed by grinding. Welds on gasket surfaces shall be ground smooth.

B. FIELD WELDING:

- 1. Field welding shall be minimized to the greatest extent possible by use of couplings and prefabrication of pipe systems at the factory. Pipe butt welds may be performed at the job site, providing the but welds are performed only with an inert gas shielded process and that other applicable specified welding requirements are rigidly adhered to.
- 2. All residue, oxide, and heat stain is to be removed from any type of field weld and the affected areas adjacent by the use of stainless steel wire brushes, followed by cleaning with an agent such as Eutectic Company's "Eucleen," or equal, followed by complete removal of the agent.

C. PREPARATION OF SURFACES TO BE WELDED:

- 1. Surfaces of joints to be welded shall be free from mill scale, slag, grease, oil, paint, rust, and other foreign material. Joints to be welded shall be wire-brushed with stainless steel wire brushes and precisely fitted before welding.

D. WEATHER CONDITIONS:

- 1. Welding shall be done only when the surfaces are completely free of any moisture. Welding of the pipe shall not be done during periods of high winds or rain unless the areas being welded are properly shielded.

E. TACK WELDS, CLIPS, AND OTHER ATTACHMENTS:

- 1. Nicks, gouges, notches, and depressions in the base metal in the area of the joint shall be repaired before the joint weld is made. Tack welds, clips, and other attachments shall be removed and defects repaired, except where the tack welds occur within the weld area and these tack welds do not exceed the size of the completed weld. Cracked tack welds shall be removed. Areas to be repaired shall be

ground to clean metal and then repaired by building up with weld metal. The repaired areas shall be ground smooth to form a plane surface with the base metal.

F. DEFECTS AND REPAIRS:

1. Welds with cracks, slag inclusions, porosity, undercutting, incomplete penetration, or which are otherwise deficient in quality or made contrary to any provisions of these specifications shall be removed by chipping or grinding throughout their depth to clean base metal. Calking or peening of welds to correct defects shall not be done. Welds found deficient in dimension but not in quality shall be enlarged by additional welding after thoroughly cleaning the surface of previously deposited metal and the adjoining plate. Weld deposits, slag, weld spatter, and projections into the interior of the pipe shall be removed by grinding.

3.03 MARKING, SHIPPING, AND STORAGE

- A. All pipe, fittings, and fabrications shall be properly marked with type, gage, and heat number. All fabricated piping shall have openings plugged and flanges secured for storage and/or transport after fabrication. All fabricated piping shall be piece-marked with identifying numbers or codes which correspond to the Contractor's layout and installation drawings. The marks will be located on the spools at opposite ends and 180 degrees apart. Pipe spools shall be loaded and blocked and lagged as necessary to ensure protection from damage during shipping. Stainless steel pipe and fittings shall be stored per manufacturer's recommendation. Dents, gouges, and scratches in stainless steel pipe and fittings are not acceptable and are reason for rejecting pipe and fittings.

3.04 FABRICATION/INSTALLATION REQUIREMENTS

- A. The piping supplier during manufacturing, fabricating and handling stages, and the Contractor during handling and installation stages, shall use extreme care to avoid the contact of any ferrous materials with the stainless steel piping. All saws, drills, files, wire brushes, etc. shall be used for stainless steel piping only. Pipe storage and fabrication racks shall be nonferrous or stainless steel or rubber-lined. Nylon slings or straps shall be used for handling stainless steel piping. Contact with ferrous items may cause rusting of iron particles embedded in the piping walls. After installation, the Contractor shall wash and rinse all foreign matter from the piping surface. All welded joints shall be treated with a pickling solution, brushed with stainless steel wire brushes and rinsed clean. If rusting of embedded iron occurs, the Contractor shall pickle the affected surface with Oakite Deoxidizer SS, or equal, scrub with stainless steel brushes, and rinse clean.

3.05 COATINGS

- A. After installation, the Contractor shall paint all steel or iron flanges, couplings, and appurtenances. Painting of the stainless steel pipe is not required. However, the Contractor shall be responsible for supplying and installing the stainless steel piping with a consistently clean surface. Identifying spool piece marks shall be removed with paint thinner or solvents and the entire stainless steel surface shall be washed with detergent and hot water and rinsed clean.

END OF SECTION

SECTION 15075

JOINT GASKETS

PART 1 GENERAL**1.01 DESCRIPTION**

- A. This section specifies rubber gaskets for push-on compression type joints used with fabricated steel pipe, steel pipe, reinforced concrete pipe, concrete cylinder pipe, and cement mortar lined and coated steel pipe.

1.02 QUALITY ASSURANCE**A. REFERENCES:**

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ASTM D395	Rubber Property--Compression Set, Test for
ASTM D412	Rubber Properties in Tension, Test for
ASTM D471	Rubber Property--Effect of Liquids, Test for
ASTM D573	Rubber--Deterioration in an Air Oven, Test for
ASTM D1149	Rubber Deterioration--Surface Ozone Cracking in a Chamber (Flat Specimens), Test for
ASTM D2240	Rubber Property--Durometer Hardness, Test for

B. TESTING:

1. Certified copies of test reports indicating that the gasket material has been tested and that the results of the tests comply with the requirements specified in paragraph 15075-2.02 shall be provided as product data.

1.03 MATERIALS

- A. Gasket stock shall be a synthetic rubber compound in which the elastomer is neoprene. The compound shall contain no less than 50 percent by volume neoprene and shall be free from factice, reclaimed rubber and other deleterious substances.

1.04 PHYSICAL REQUIREMENTS

- A. The compound shall meet the following physical requirements when tested in accordance with the specified ASTM standards.
- B. TENSILE (ASTM D412):
 - 1. The tensile strength shall be 1500 psi minimum and the ultimate elongation shall be 350 percent minimum.
- C. HARDNESS (ASTM D2240, TYPE A DUROMETER):
 - 1. The compound shall have a hardness in the range of 35 to 50 for concrete spigots and 50 to 65 for steel spigots.
- D. COMPRESSION SET (ASTM D395):
 - 1. The compression set shall not exceed 20 percent when compressed for 22 hours at 70 degrees C.
 - 2. The test specimens shall be circular discs cut from the gaskets. Test specimens shall be 0.500 (\pm 0.005 - 0.025) inches in height. The diameter of the test specimen shall be that of the gasket but not to exceed 1.129 ± 0.010 inches in diameter.
- E. AGING (ASTM D573):
 - 1. The test specimen deterioration shall be less than 20 percent reduction in tensile strength, 40 percent reduction in ultimate elongation, and 15 points increase in hardness.
- F. EFFECT OF LIQUIDS (ASTM D471):
 - 1. The maximum volume change in oil and in water shall be as follows:
 - a. Oil: 100 percent in ASTM oil No. 3.
 - b. Water: 15 percent.
 - 2. The test specimens shall have a thickness of 0.080 ± 0.005 inches and shall be circular discs cut from the gasket.
- G. OZONE CRACKING (ASTM D1149):
 - 1. The test specimen shall be a gasket loop mounted to give at least 20 percent elongation. There shall be no cracking visible at two times magnification of the gasket after 100 hours exposure to 1 mg/l ozone at 40 degrees C.

1.05 PRODUCT DATA

- A. In accordance with Section 01330, the Contractor shall provide certified copies of test reports specified in paragraph 15075-1.02 B.

PART 2 EXECUTION

- A. The gaskets shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 15085

PIPING CONNECTIONS

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section specifies the following methods of connecting metallic piping: flanges, threading, mechanical couplings, equipment connection fittings, dielectric unions, and welding.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B18.2.1	Square and Hex Bolts and Screws Inch Series
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI B31.1	Power Piping
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications
ASTM B98	Copper-Silicon Alloy Rod, Bar and Shapes
ASTM F37	Standard Test Methods for Sealability of Gasket Materials
ASTM F104	Standard Classification System for Nonmetallic Gasket Materials
ASTM F152	Standard Test Methods for Tension Testing of Nonmetallic Gasket Materials
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in.
AWWA C219	Bolted, Sleeve-Type Couplings for Plain-End Pipe

Reference	Title
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
AWWA C606	Grooved and Shouldered Joints
AWWA M11	Steel Pipe-A Guide for Design and Installation
NSF 61	Drinking Water System Components - Health Effects

1.03 SUBMITTALS

- A. In addition to the material listed in the detailed specification, the following submittals shall be provided in accordance with Section 01330:

PART 2 PRODUCTS

2.01 FLANGE ASSEMBLIES

A. FLANGES:

1. GENERAL: Flanges shall either be flat flanges or convoluted ring flanges as specified in the following paragraphs.
2. FLAT FLANGES: Cast iron flanges shall be faced in accordance with ANSI B16.1. Where companion flanges are used, the flanges on pipe shall be refaced to be flush with the companion flange face. Class 150 and Class 300 forged steel flanges shall be raised face conforming to ANSI B16.5. Lightweight slip-on flanges shall be plain face conforming to AWWA C207, Class B and ANSI B16.5. Unless otherwise specified, steel flanges shall be ANSI B16.5, Class 150 or AWWA C207, Class D. Class E AWWA flanges shall be provided where test pressure exceeds 175 psi. Plain faced flanges shall not be bolted to raised face flanges.
3. CONVOLUTED RING FLANGES: Convoluted ring flanges shall be ductile iron, forged steel or cast stainless steel, designed to bear on hubs welded to the pipe and shall be as manufactured by Improved Piping Products. The Owner's Representative knows of no equal. The flange joints shall be rated for not less than 150 percent of the test pressures listed in Section 15050 and shall conform to the requirements of ANSI B 16.5 and AWWA C207. The flange manufacturer shall be prepared to demonstrate, by certified pressure test that the flanges will meet these requirements.

B. GASKETS:

1. Gasket material shall be as specified in paragraph 15085-2.03.
2. Gaskets for plain faced flanges shall be the full face type. Thickness shall be 1/16 inch for pipe 10 inches and less in diameter and 1/8 inch for pipe 12 inches and larger in diameter. Unless otherwise specified, gaskets for raised face flanges shall match the raised face and shall be 1/16 inch thick for pipe 3-1/2 inches and less in diameter and 1/8 inch thick for pipe 4 inches and larger.

C. BOLTS:

1. Flange assembly bolts shall be ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts. Threads shall be ANSI B1.1, standard coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. Bolt length shall conform to ANSI B16.5.

2. Unless otherwise specified, bolts shall be carbon steel machined bolts with hot pressed hexagon nuts. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.

2.02 MECHANICAL COUPLINGS

A. SLEEVE-TYPE COUPLINGS:

1. Unless otherwise specified, sleeve-type mechanical pipe couplings shall be Smith-Blair Type 411, Dresser Style 38, or equal, with the stop removed from the middle ring. Reducing couplings shall be Smith-Blair Type 415, Dresser Style 62, or equal. Sleeve-type flanged coupling adapters shall be Smith-Blair Type 913, Dresser Style 128, or equal. Insulating couplings shall be Smith-Blair Type 416, Dresser Style 39, or equal.
2. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04, or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
3. Gaskets shall be as specified in paragraph 15085-2.03 and AWWA C111.

B. DISMANTLING JOINTS

1. Dismantling joints may be used as takedown couplings in accordance with paragraph 15085-3.03. Dismantling joints shall fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment. Thrust restraint shall be provided by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts. Design of equipment connection fittings shall conform to AWWA C219. Sleeves shall be carbon steel or as specified for the specific piping system. Pressure rating of flange adapters shall equal or exceed the pressure rating of mating flanges. All metal portions of equipment connection fittings, with the exception of 316 stainless steel components, shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. Dismantling joints shall be Romac DJ-400, Smith Blair 975, or Crane-Viking Johnson Dismantling Joint.

2.03 GASKETS

A. Gaskets designated in Section 15050 shall be as follows:

1. EPDM: ethylene-propylene-dieneterpolymer.
2. Neoprene: neoprene.
3. Nitrile: nitrile (Buna N).

4. Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder; ASTM F104 (F712400), 2500 psi (ASTM F152), 0.2 ML/HR LEAKAGE FUEL A (ASTM F37).
5. Compressed gasketing consisting of organic fibers (Kevlar) and SBR binder; ASTM F104 (F712400), 2500 PSI (ASTM F152), 0.1 ml/hr leakage Fuel A (ASTM F37).
6. Gylon gasketing, Garlock Style 3500, 2000 psi (ASTM F152), 0.22 ml/hr Fuel A (ASTM F37).
7. Gylon gasketing, Garlock Style 3510, 2000 psi (ASTM F152), 0.04 ml/hr Fuel A (ASTM F37).
8. Gylon gasketing, Garlock Style 3504, 2000 psi (ASTM F152), 0.12 ml/hr Fuel A (ASTM F37).
9. TFE: noncreeping tetrafluoroethylene (TFE) with insert filler.
10. PTFE bonded EPDM: PTFE bonded to EPDM in full-face gasket having concentric-convex molded rings; Garlock Stress Saver 370 or equal.

2.04 THREAD

- A. Pipe thread dimensions and size limits shall conform to ANSI B1.20.1.

2.05 COATINGS

- A. Unless otherwise specified, flange assemblies and mechanical type couplings for buried installation shall be field coated.

2.06 PRODUCT DATA

- A. In accordance with Section 01330, the Contractor shall provide for each welder, a welder qualification certificate indicating the welder is certified for pipe welding in accordance with ASME Boiler and Pressure Vessel, Section IX. Each welder's certificate shall be provided to the Owner's Representative prior to that welder working on the job.

PART 3 EXECUTION

3.01 PIPE CUTTING, THREADING AND JOINTING

- A. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B31.1.

3.02 PIPE WELDING

- A. Pipe shall be welded by ASME-certified welders using shielded metal arc, gas shielded arc or submerged arc welding methods.
- B. Welds for piping systems not specified above shall be made in accordance with AWWA C206.

3.03 TAKEDOWN COUPLINGS

- A. Takedown couplings shall be screw unions, flanged or grooved end mechanical coupling type joints and shall be provided as specified. Flanged or grooved end joints shall be employed on pipelines 2-1/2 inches in diameter and larger. Where piping passes through

walls, takedown couplings shall be provided within 3 feet of the wall, unless specified otherwise.

- B. A union or flanged connection shall be provided within 2 feet of each threaded end valve.

3.04 FLEXIBILITY

- A. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints (or a single Flexijoint) as specified on the buried pipe within 2 feet of the structure for 2-inch through 6-inch diameter pipe; within 3 feet of the structure for 8-inch through 24-inch diameter pipe; and within one and one-half pipe diameters of the structure for larger pipe. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

3.05 EQUIPMENT CONNECTION FITTINGS

- A. Where shown, equipment connection fittings shall be provided between field piping systems and equipment inlet and outlet connections.

END OF SECTION

SECTION 15103
BUTTERFLY VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:

1. This section specifies butterfly valves for gas service.
 - a. Valves used in the following piping systems shall be designated Type B:

Piping systems
4A

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI FCI 70-2	Control Valve seat Leakage Classifications
ASTM A48	Gray Iron Castings
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A216/A216M	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A436	Austenitic Gray Iron Castings
ASTM A536	Ductile Iron Castings
AWWA C504	Rubber-Seated Butterfly Valves

PART 2 PRODUCTS

2.01 MATERIALS

A. TYPE B:

1. Type B valves shall be constructed of the following materials unless otherwise specified:

Component	Material
Shaft	Stainless steel, ASTM A582, Type 416
Disc	Cast iron, ASTM A126, Class B
Seat sealing surface	Neoprene
Body	Cast iron, ASTM A126, Class B
Disc edge	Nickel

2.02 MANUFACTURE

A. GENERAL:

1. Valves shall be the stub or through shaft design. Wafer type valves are not acceptable for buried service. Unless otherwise specified, valve flange drilling shall be per ANSI B16.1, Class 125.

B. TYPE B:

1. Valves shall be rated at 175 psig and provide driptight shutoff up to the full valve rating on dead-end or isolation service. Seat shall be mechanically held in place and shall be field replaceable. Valve ends shall be as specified in Section 15050.
2. Type B valves, size 2 through 20 inches, shall have seats that are bonded to a rigid reinforcing ring.
3. Valve shall comply with ANSI FCI 70-2 Leakage Class IV.

2.03 MANUAL OPERATORS

A. GENERAL:

1. Manual operators shall be designed in accordance with AWWA C504 and shall have a disc position indicator designating the opened and closed position of the valve.

B. TYPE B.

1. Operators for Type B valves 6 inches in diameter and smaller shall be latch lock levers. Valves shall be capable of being locked in at least five intermediate positions between fully open and fully closed.
2. Operators for Type B valves 8 inches in diameter and larger shall be the traveling nut or worm gear Type. Operators for exposed service shall be gasketed for weatherproof service.

2.04 PRODUCT DATA

- A. Affidavits of compliance with AWWA C504 shall be provided in accordance with Section 01330.

PART 3 EXECUTION

A. Valves shall be installed in accordance with the manufacturer's recommendations.

PART 4 VALVE SCHEDULE

P&ID	Valve Tag	Valve Type	Size, inches	Pipe	Location	Function
P1	-	Butterfly	8	DG	DG piping to Waste Gas Burner #2	Isolation of digester Waste Gas Burner flow meter 20FE30101
P1	-	Butterfly	6	DG	DG piping to Waste Gas Burner #2	Balancing valve for new bypass valve 725FCV6901
P1	-	Butterfly	10	DG	DG piping to Waste Gas Burner #2	Isolation of digester Waste Gas Burner bypass valve 725FCV6901
P1	-	Butterfly	10	DG	DG piping to Waste Gas Burner #2	Isolation of digester Waste Gas Burner bypass valve 725FCV6901
P1	-	Butterfly	8	DG	DG piping to Waste Gas Burner #2	Isolation of digester Waste Gas Burner PCV

END OF SECTION

SECTION 15147 SOLENOID VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:

1. This section specifies 2-way solenoid valves, direct operated type, for control of process fluids.

B. TYPE:

1. Valves with piping connections less than 1-1/2 inches in diameter shall be direct-acting type.

C. DESIGN REQUIREMENTS:

1. Unless otherwise specified, solenoid valves shall be designed to seal or unseal the pressurized (supply) port upon the action specified in the paragraph 1.03, Solenoid Valve Schedule.
2. Valves shall be listed by Underwriters Laboratories Inc. in accordance with UL 429 and UL 1002. Solenoid valves for gas service shall be approved by Factory Mutual Engineering Corporation. The minimum acceptable operating pressure differential for pilot operated valves shall be 5 psi.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM A48	Gray Iron Castings
UL 429	Electrically Operated Valves
UL 1002	Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G

1.03 SOLENOID VALVE SCHEDULE

Service ^a	Solenoid valve number	Line size, inches	Valve size, inches	Operating pressure differential, Max, psig	Operating temp., maximum, degrees F	NEMA Enclosure Type	Unpowered position: Normally Open (NO) or Normally Closed (NC)	Voltage
Natural Gas	1	Match Existing	Match Existing	50	125	Type 7	NC	120
Natural Gas	2	Match Existing	Match Existing	50	125	Type 7	NC	120

^aSee Section 15050 for description of service fluids.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

B. DIRECT ACTING TYPE:

1. Candidate manufacturers include:
 - a. Automatic Switch Company (ASCO)
 - b. Honeywell-Skinner
 - c. or equal

2.02 MATERIALS**A. DIRECT ACTING TYPE:**

1. Materials of construction shall be as follows:

Component	Material
Body	Brass or stainless steel, Type 304
Seal	Teflon or Buna-N
Disc	Teflon or Buna-N

2.03 EQUIPMENT**A. GENERAL:**

1. Solenoid valves shall be rated for continuous duty at 120 volts AC as indicated. Valves shall be threaded for sizes 2-inch and smaller.

B. DIRECT ACTING TYPE AND PILOT TYPE:

1. Solenoid valves shall be suitable for the area location and usages as indicated in the schedule with fully encapsulated Class H coils. Enclosure type:
 - a. NEMA 7, explosion proof

2.04 PRODUCT DATA

- A. Manufacturer's product data shall be provided in accordance with Section 01330.

PART 3 EXECUTION

- A. Solenoid valves shall be installed in accordance with the manufacturer's recommendations.

END OF SECTION

DIVISION 16 ELECTRICAL

16050	Common Work Results for Electrical
16052	Hazardous Classified Area Construction
16060	Grounding and Bonding
16070	Hangers and Supports
16075	Electrical Identification
16080	Commissioning of Electrical Systems
16123	600 Volt or Less Wires and Cables
16130	Conduits
16134	Boxes
16140	Wiring Devices
16150	Low-Voltage Wire Connections
16611	Uninterruptible Power Supply

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Electrical Work.
 - 2. General requirements for electrical submittals.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility to schedule and coordinate the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Document 00720 - General Conditions.
 - b. Section 01140 - Work Restrictions.
 - c. Section 01292 - Schedule of Values.
 - d. Section 01324 - Progress Schedules and Reports.
 - e. Section 01329 - Safety Plan.
 - f. Section 01330 - Submittal Procedures.
 - g. Section 01410 - Regulatory Requirements.
 - h. Section 01770 - Closeout Procedures.
 - i. Section 01782 - Operation and Maintenance Data.
 - j. Section 16075 - Electrical Identification.
 - k. Section 16130 - Conduits.
- C. Interfaces to equipment, instruments, and other components:
 - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700.
 - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely

accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:

- a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
5. Loop drawings:
- a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
 - 1) Conduit numbers and associated signal(s) contained within each conduit.
 - 2) Wire numbers.
 - 3) Equipment terminal numbers.
 - 4) Junction boxes and signal(s) contained within each junction box.
 - 5) Equipment power sources, and associated circuit numbers.
 - 6) As-built drawings detailing wiring.
- D. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections, including packaged mechanical systems, LCPs, VCPs, etc.
 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
 3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.
- E. Special subcontractor requirements:
1. As specified elsewhere in this Section, provide the Work specified in the Electrical Specifications by a qualified electrical subcontractor.
- F. Contract Documents:
1. General:
 - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
 2. Specifications:
 - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
 3. Contract Drawings:
 - a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make

changes required to accommodate differences in equipment dimensions.

- 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:

- 1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.

d. Schematic diagrams:

- 1) All controls are shown de-energized.
- 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
- 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
- 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
- 5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

G. Alternates/Alternatives:

1. Coordinate with Document 00720 for substitute item provisions.

H. Changes and change orders:

1. As specified in Document 00720.

1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this Section.
 - a. American National Standards Institute (ANSI).
 - b. American Society of Civil Engineers (ASCE):
 - 1) Minimum Design Loads for Buildings and Other Structures.
 - c. ASTM International (ASTM).
 - d. Illuminating Engineering Society (IES). Institute of Electrical and Electronics Engineers (IEEE).

- e. Insulated Cable Engineers Association (ICEA).
 - f. International Code Council (ICC).
 - 1) International Code Council Evaluation Service (ICC-ES).
 - a) AC 156 – Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
 - g. International Society of Automation (ISA).
 - h. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - i. National Fire Protection Association (NFPA):
 - 1) 70 - National Electric Code (NEC).
 - j. National Institute of Standards and Technology (NIST).
 - k. Underwriters' Laboratories, Inc. (UL).
- B. Compliance with laws and regulations:
- 1. As specified in Document 00720.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
- 1. IEEE.
 - 2. NETA.
 - 3. IES.
 - 4. ISA.
 - 5. NEC.
 - 6. NEMA.
 - 7. NFPA.
 - 8. NIST.
- B. Specific definitions:
- 1. FAT: Factory acceptance test.
 - 2. ICSC: Instrumentation and controls subcontractor.
 - 3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
 - 4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
 - 5. PCIS: Process control and instrumentation system.
 - 6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
 - 7. Space: That portion of the switchgear, motor control center, panel-board, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
 - 8. Spare: That portion of the switchgear, motor control center, panel-board, switchboard or control panel that physically contains a device with no load connections to be made.

9. System supplier: Refer to Quality Assurance in this Section.
10. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
11. Unequipped space: That portion of the switchgear, motor control center, panel-board, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
 - a. The Electrical Drawings are schematic in nature; use the Structural and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work, including heating, ventilating, and air conditioning.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
5. Demolition:
 - a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment and render the equipment safe.
 - b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
 - c. Salvage electrical equipment as indicated on the Drawings.
 - d. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).
 - e. Conduit:
 - 1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
 - a) Remove exposed conduit to the point of encasement or burial.
 - b) Cut conduit flush and plug or cap encased or buried conduit.
 - 2) Where conduits are to remain in place and removal is not indicated on the Drawings:
 - a) Cap conduit open ends.
 - b) Re-label empty conduits as spare.

- f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
 - g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
 - h. Provide new typewritten schedules for all modified panel-boards.
 - 6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
 - 7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
 - a. As specified in the Contract Documents.
 - 8. Defective work:
 - a. As specified in Document 00720.
- B. Operating facility:
 - 1. As specified in Section 01140.
 - 2. The Durham AWTF is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
 - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
 - 3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 - 4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 and this Section.
- B. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 2. Furnish the submittals required by each section in the Electrical Specifications.
 3. Adhere to the wiring numbering scheme specified in Section 16075 throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Seismic requirements:
1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in 2014 Oregon Structural Specialty Code, or the latest adopted version.
 2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
 - a. Statement of seismic qualification, and special seismic certification:
 - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410, including the requirements of ASCE 7, Chapter 13.
 - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with $I_p = 1.5$." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
 - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
 - c. Anchoring design calculations and details:
 - 1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of 2014 Oregon Structural Specialty Code, or the latest adopted version.
 3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
 - a. Temporary or moveable equipment.
 - b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
 - c. Distribution equipment anchored to the structure and having a total unit weight of 5 pounds per linear foot, or less.
- D. Submittal organization:
1. First page:
 - a. Specification section reference.

- b. Name and telephone number of individuals who reviewed submittal before delivery to Engineer.
 - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
 - d. Place for Contractor's review stamp and comments.
 - 2. Next pages:
 - a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
 - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
 - 1) In the order that the comments or questions were presented throughout the submittal.
 - 2) Referenced by index section and page number on which the comment appeared.
 - 3) Acceptable responses to Engineer's comments are either:
 - a) Engineer's comment or change is accepted and appropriate changes are made.
 - b) Explain why comment is not accepted or requested change is not made.
 - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
 - 5) No further review by the Engineer will be performed until a response for previous comments has been received.
 - 3. Remaining pages:
 - a. Actual submittal data:
 - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.
- E. Submittal requirements:
- 1. Furnish submittals that are fully indexed with a tabbed divider for every component.
 - 2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
 - 3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
 - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
 - 4. Submit copies of shop drawings, and product data:
 - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.

5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
 - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
 - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
 - c. Acceptance of any exception is at the sole discretion of the Engineer.
 - 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
 - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific submittal requirements:
 - a. Shop drawings:
 - 1) Required for materials and equipment listed in this and other sections.
 - 2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - 3) Shop drawings requirements:
 - a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - b) Locations of conduit entrances and access plates.
 - c) Component layout and identification.
 - d) Schematic and wiring diagrams with wire numbers and terminal identification.
 - e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - g) Weight.
 - h) Finish.
 - i) Nameplates:
 - (1) As specified in Section 16075.
 - j) Temperature limitations, as applicable.
 - b. Product data:
 - 1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - 2) Include:
 - a) Catalog cuts.
 - b) Bulletins.
 - c) Brochures.

- d) Quality photocopies of applicable pages from these documents.
 - e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - f) Identify model number and options for the actual equipment being furnished.
 - g) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Detailed sequence of operation for all equipment or systems.
- F. Operation and maintenance manuals:
 - 1. As specified in Section 01782.
 - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 4 weeks before energization start-up and/or commissioning.
 - 3. Additional operation and maintenance manual requirements:
 - a. Completely index manuals with a tab for each section:
 - 1) Each section containing applicable data for each piece of equipment, system, or topic covered.
 - 2) Assemble manuals using the approved shop drawings, and include, the following types of data:
 - a) Complete set of 11-inch by 17-inch drawings of equipment.
 - b) Complete set of 11-inch by 17-inch drawings of the control system.
 - c) Complete set of control schematics.
 - d) Complete parts list for all equipment being provided.
 - e) Catalog data for all products or equipment furnished.
- G. Material and equipment schedules:
 - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- H. Schedule of values:
 - 1. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- I. Roof penetrations:
 - 1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- J. Record Documents:
 - 1. Furnish as specified in Section 01770.
 - 2. Provide Record Documents of all Electrical Drawings.

3. Record Drawing requirements:
 - a. Update Record Drawings weekly.
 - b. Record Drawings must be fully updated as a condition of the monthly progress payments.
 - c. Submit Record Drawings upon completion of the Work for final review.
 - d. Clearly and neatly show all changes including the following:
 - 1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
 4. Shop drawings:
 - a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
 - 1) Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch using Bond paper.
 - 2) Provide electronic copies of these documents on CD-ROM disks in Auto-Cad Version 2018 by Autodesk and PDF. Size all drawings to be readable and legible on 11-inch by 17-inch media.
 - b. Furnish written information prepared specifically for this Project using Microsoft Word 2016 and PDF and printed on 8.5-inch by 11-inch plain bond paper:
 - 1) Provide electronic copies of these documents on CD-ROM disks.
 5. Review and corrections:
 - a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - b. Promptly correct and re-submit record documents returned for correction.
- K. Test reports:
1. As specified in Section 01330.
 2. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of the person conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 - g. Each report signed by the person responsible for the test.
 3. Additional requirements for acceptance test reports are specified in Section 16950.
- L. Calculations:
1. Where required by specific Electrical Specifications:
 - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

- M. Factory acceptance test:
 1. As specified in Section 01330.
 2. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- B. System supplier responsibilities:
 1. Requirements as specified in the Instrumentation and Control Specifications.
 2. System supplier:
 - a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and Instrumentation and Control Specifications, and shown on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.
 3. Contractual relationship:
 - a. Form a contractual relationship between the electrical subcontractor and the ICSC.
 - b. Requirements for the first tier subcontractor:
 - 1) Contract directly with the Contractor.
 - 2) Be either the electrical subcontractor or the ICSC.
 - c. Requirements for the second tier subcontractor:
 - 1) A division of the first tier subcontractor, or
 - 2) A joint venture with the first tier subcontractor, or
 - 3) A subcontractor to the first tier subcontractor.
 - d. The system supplier manages, directs, and supervises all of the Work of its second tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system, including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, Electrical Specifications, and Instrumentation and Control Specifications:
 - 1) Provide any additional conduit, wire, etc.
 - 2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
 - 3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Shipping precautions:
 1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 2. Place dehumidifiers, when required, inside the polyethylene coverings.
 3. Skid-mount the equipment for final transport.

4. Provide lifting rings for moving without removing protective covering.
 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- B. Delivery and inspection:
1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.
- C. Special instructions:
1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 2. Seismic load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in 2014 Oregon Structural Specialty Code.
 3. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329.
 4. Outdoor installations:
 - a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
 - 1) Provide all wiring necessary to power these devices.
- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
 3. NEMA Type 4X: Made from corrosion resistant materials (316 stainless steel or approved equal) and are intended for indoor or outdoor use, primarily to protect

equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.

4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
5. NEMA Type 6: Rated for submergence.
6. NEMA Type 6P: Rated for prolonged submergence.
7. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052.
8. NEMA Type 8: Intended for installation in either indoor or outdoor locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) and the equipment is oil-immersed, meeting the requirements outlined in Section 16052.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:
2. Provide stainless steel NEMA 4X enclosures and supports, and PCS conduit type for all Electrical work not included in the following table unless otherwise indicated on the Drawings.

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS	ANCHOR MATERIALS
Electrical/Control Rooms	NEMA 12	GRC	C	SST	SST
Waste Gas Burner	NEMA 4X, NEMA 7 when inside hazardous boundary	PCS	W, X	SST	SST
Outdoor	NEMA 4X when outside hazardous boundary	PCS	W	SST	SST

3. Modify conduit runs as specified in Section 16130.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:

1. As specified in Section 01324 Construction Schedule.
 2. Testing requirements are specified in Section 16950 and other sections.
 3. General scheduling requirements are specified in Section 01324.
 4. Work restrictions and other scheduling requirements are specified in Section 01140.
- B. Pre-submittal conference:
1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
 2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, must attend.
- C. Factory acceptance testing:
1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
 - a. Indicate the desired dates for inspection and testing.
 - b. Schedule the FAT after approval of the FAT procedures submittal:
 - 1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 - 2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

- A. Warrant the Electrical Work as specified in Document 00720:
1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in Document 00720.
- C. Stainless steel:
 - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.
 - 3. Provide finished material free of any burrs or sharp edges.
 - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
 - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
 - 6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.03 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.
- B. Arrange with all manufacturers of the electrical equipment, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
 - 1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.
- C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

- A. The electrical subcontractor is encouraged to examine the premises completely before bidding. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

- B. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete electrical system:
 - 1. Install all extra conduits, cables, and interfaces as may be necessary to provide complete and operating electrical and PCIS systems.

3.02 INSTALLATION

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. Cutting and patching:
 - 1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
 - a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
 - 1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
 - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
 - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
 - b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
 - 2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
 - a. 3M CP 25WB+ Caulk.
 - b. 3M Fire Barrier Putty.
 - 3. Seal around conduit penetrations of below grade walls with a waterproof, non-shrink, non-metallic grout, unless otherwise indicated on the typical installation details:
 - a. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

- D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
 - 1. Install all conduits and equipment in accordance with working space requirements as outlined in the NEC.
 - a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
 - 2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
 - a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
 - 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
 - 4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- E. Earthwork and concrete:
 - 1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
 - a. Requirements as specified in the Contract Documents.
- F. Roof penetrations:
 - 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- G. Terminations:
 - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- H. Miscellaneous installation requirements:
 - 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00700.
 - 2. Location of manholes and pull-boxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pull-boxes with Mechanical and Civil Work.
 - 3. Provide additional manholes or pull-boxes to those shown where they are required to make a workable installation.
- I. Labeling:
 - 1. Provide all nameplates and labels as specified in Sections 16075 and Section 16305.
- J. Equipment tie-downs:
 - 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
 - 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.03 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Allow for inspection of electrical system installation as specified in Section 16080.
 - 2. Provide any assistance necessary to support inspection activities.
 - 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with the Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect raceway installation for quality workmanship and adequate support.
 - g. Inspect cable terminations.
 - h. Schedule inspection of all mounting of electrical devices and all penetration and connections to structures.
 - 4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950.
- B. Field testing:
 - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
 - 2. Perform the acceptance tests as specified in Section 01756 and 16080.
 - 3. Record results of the required tests along with the date of test:
 - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
 - 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.04 CLEANING

- A. As specified in Section 01770.
- B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
- C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
 - 1. Use of compressors or air blowers for cleaning is not acceptable.
- D. As specified in other sections of the Contract Documents.

3.05 DEMONSTRATION AND TRAINING

- A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections.

3.06 PROTECTION

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

END OF SECTION

SECTION 16052

HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16130 - Conduits.
 - d. Section 16134 - Boxes.
 - e. Section 16140 - Wiring Devices.
 - f. Section 16150 - Low Voltage Wire Connections.

1.02 REFERENCES

- A. As specified in Section 16050.

1.03 DEFINITIONS

- A. As specified in Section 16050.
- B. Specific definitions:
 - 1. For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.

1.05 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Regulatory requirements:

1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
3. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.07 PROJECT OR SITE CONDITIONS

- A. The following areas are classified Class I, Division 1:
 1. Refer to the drawings for classification boundaries.
- B. The following areas are classified Class 1, Division 2:
 1. Refer to the drawings for classification boundaries.

PART 2 PRODUCTS

2.01 COMPONENTS

- A. Conduit and sealing fittings:
 1. As specified in Section 16130.
- B. Conduit boxes and bodies:
 1. As specified in Section 16134.
- C. Wiring devices:
 1. As specified in Section 16140.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Conduit installation:
 1. As specified in Section 16130.
 2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
 3. Make all conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
 4. Flexible conduit:
 - a. Class I Division 1 hazardous areas:
 - 1) Approved and marked suitable for Class I Division 1.

- 2) Listed for compatibility with the group type atmosphere where used.
 - b. Class I Division 2 areas:
 - 1) Liquid-tight metal conduit with approved fittings.
 - c. Maximum length as specified in Section 16130.
- C. Sealing fittings:
- 1. Provide an approved seal, no more than 12 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
 - a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies similar to "L", "T", and "X" may be installed between the sealing fitting and the enclosure.
 - 2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
 - a. Seals are required in all conduit connections to the compartment containing splices and must be within 12 inches of the enclosure.
 - 3. Install a conduit seal within 12 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
 - 4. For underground conduits entering or leaving a classified location or between Class I Division 1 and Division 2 locations:
 - a. Provide a conduit seal at both points where the conduit emerges from the ground:
 - 1) Place the conduit seal within 18 inches of finished grade.
 - 2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.
 - 5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
 - a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
 - 6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
 - 7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
- D. Boxes and fittings:
- 1. Class I Division 1 areas:
 - a. Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.

2. Class I Division 2 areas:
 - a. Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.
- E. Outlet boxes and bodies:
 1. Provide conduit bodies and boxes suitable for the conduit system as specified in Section 16130.
 2. Class I Division 2 areas:
 - a. Boxes not containing arcing parts:
 - 1) Material and NEMA ratings as specified in Section 16050.
 - 2) Pressed metal boxes are not allowed.
 - b. Provide heavy duty cast construction type conduit fittings and joints:
 - 1) Explosion proof rated fittings and joints are not necessary.
 - c. Any enclosure containing arcing parts, etc. shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.
- F. Motor connections:
 1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
 - a. First - Conduit.
 - b. Second - Explosion proof flexible coupling.
 - c. Third - Sealing fitting.
 - d. Fourth - Explosion proof union.
 - e. Fifth - Connection to the motor terminal box.
 2. Wiring connections to motor leads shall be as specified in Section 16150.
 3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

3.01 FIELD QUALITY CONTROL

- A. As specified in Section 16050.
- B. Obtain inspection and approval from the Engineer before and after each seal is poured.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Grounding electrodes.
 - 2. Grounding electrode conductors.
 - 3. Equipment grounding conductors.
 - 4. Ground connections.
 - 5. General requirements for grounding.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16080 - Commissioning of Electrical Systems.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.
- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.
- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16080, shall be:
 - 1. 5 ohms or less for industrial systems.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 WARRANTY

- A. As specified in Section 16050.

1.09 SYSTEM START-UP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Compression connectors: One of the following or equal:
 - 1. FCI Burndy.
 - 2. Thomas & Betts.

- B. Ground rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Conex.
- C. Ground cable: One of the following or equal:
 - 1. Nehring.
 - 2. Harger.
 - 3. Southwire.
- D. Precast ground well boxes: One of the following or equal:
 - 1. Brooks Products, 3-RT Valve Box.
 - 2. Christy Concrete Products, G12 Valve Box.

2.02 MATERIALS

- A. Ground rod:
 - 1. Minimum: 3/4-inch diameter, 10 feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
 - a. The copper-to-steel bond shall be corrosion resistant.
 - 3. In accordance with UL 467.
 - 4. Sectional type joined by threaded copper alloy couplings.
 - 5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
 - 1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B 8.
 - c. Bare copper in accordance with ASTM B 3.
 - 2. Size is as indicated on the Drawings, but not less than required by the NEC.
- C. Compression connectors:
 - 1. Manufactured of high copper alloy specifically for the particular grounding application.
 - 2. Suitable for direct burial in earth and concrete.
 - 3. Identifying compression die number inscription to be impressed on compression fitting.
- D. Equipment grounding conductors:
 - 1. Conductors shall be the same type and insulation as the load circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
 - 2. Minimum size in accordance with the NEC.

- E. Grounding electrode conductors:
 - 1. Minimum size in accordance with the NEC.
- F. Main bonding jumpers and bonding jumpers:
 - 1. Minimum size in accordance with the NEC.

2.03 ACCESSORIES

- A. Precast ground well boxes:
 - 1. Minimum 10 inch interior diameter.
 - 2. Traffic-rated cast iron cover.
 - 3. Permanent "GROUND" marking on cover.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 - 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 - 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.
- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
 - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.

2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- J. Ground connections:
1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
 2. Make ground connections in accordance with the manufacturer's instructions.
 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
- K. Grounding electrode system:
1. Ground ring:
 - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
 2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 - d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- L. Shield grounding:
1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
 - a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.

2. Terminate the shield drain wire on a dedicated terminal block.
3. Use manufacturer's terminal block jumpers to interconnect ground terminals.
4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Where indicated on the Drawings, install ground rods in precast ground wells.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.
- B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.03 ADJUSTING

- A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
 1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.04 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16070
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mounting and supporting electrical equipment and components.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01410 - Regulatory Requirements.
 - c. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Conform to the requirements of the Building Code as specified in Section 01410.
 - 2. Demonstrate the following using generally accepted engineering methods:
 - a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
 - b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.

3. Design loading and anchoring requirements:
 - a. As indicated in the Building Code unless otherwise specified.
 - b. Seismic loading requirements:
 - 1) Freestanding or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050.
 - c. Wind loading requirements:
 - 1) All exterior freestanding equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050.
 - d. Minimum safety factor against overturning: 1.5.
 - e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.
- B. Performance requirements:
 1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 1. Supports:
 - a. Materials.
 - b. Geometry.
 - c. Manufacturer.
 2. Hardware:
 - a. Materials.
 - b. Manufacturer.
- C. Shop drawings:
 1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
 2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
 - b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
 3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.
- D. Installation instructions:

1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 WARRANTY

- A. As specified in Section 16050.

1.10 SYSTEM STARTUP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. Thomas & Betts.
 2. Power-Strut.
 3. Unistrut.
 4. Cooper B-Line.
 5. Robroy.
 6. Aickinstrut.

2.02 MATERIALS

- A. Use materials appropriate for the area as specified in Section 16050.
- B. Stainless steel:
 1. Supports:
 - a. In accordance with ASTM A 240.
 - b. ANSI Type 316 material.
 2. Hardware:
 - a. ANSI Type 316 material.
- C. PVC coated galvanized steel:

1. Supports:
 - a. Hot dip galvanized steel as specified in this Section.
 - b. PVC coating thickness of 10 to 20 mils.
2. Hardware:
 - a. ANSI Type 316 material.

2.03 ACCESSORIES

- A. Anchor bolts:
 1. As specified in Section 05190.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
 1. Provide the necessary sway bracing to keep trapeze type structures from swaying.
- C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
 1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
- D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
 1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
 2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
 3. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
 - a. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
- E. Corrosion protection:
 1. Isolate dissimilar metals, except where required for electrical continuity.
 - a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
- F. Raceway:
 1. Furnish all conduit racks and trapeze structures needed to support the raceway from the structure.
 - a. Group conduits and position on racks to minimize crossovers.
 - b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.

- G. Anchoring methods:
 - 1. Solid concrete: Anchor bolts, anchor rods or post-installed anchors
 - 2. Metal surfaces: Machine screws or bolts.
 - 3. Hollow masonry units: Post-installed anchors.
- H. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
- I. Re-coat all scratches, cuts, and drilled holes in galvanized surfaces with CRC "Zinc-It" or similar product.
- J. Re-coat all drilled holes and cut surfaces on PVC-coated materials.
- K. Seal all drilled holes and cut surfaces on fiberglass materials.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16075
ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes Requirements for:
 - 1. Identifying electrical, instrumentation, and process equipment and components.
 - 2. Material, manufacturing and installation requirements for identification devices.
- B. Related Specifications:
 - 1. Division 11.
 - 2. Division 15.
 - 3. Division 16.
 - 4. Division 17.

1.02 REFERENCES

- A. Refer to Section 16050.

1.03 DEFINITIONS

- A. Refer to Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Nameplates:
 - 1. Provide a nameplate for each piece of mechanical equipment, process equipment, valve, switch, receptacle, controller, instrument transmitter, instrument power supply, solenoid, disconnect switch, relay and for any other control device or major item of electrical equipment, either located in the field or within panels.
 - 2. Provide all nameplates of identical style, color, and material throughout the facility.
- B. Wire Numbers:
 - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Control and Instrumentation wires and cables shall be assigned a unique identification number following OWNER standards.
 - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number.
 - d. Multiconductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
 - 1) Label armored multiconductor cable using the conduit number following the requirements for conduit markers in Section 16130.
 - e. Spare wiring and terminals shall be tagged as spares.

2. Power cables and wires shall be assigned a unique identification number as specified by OWNER.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01330 and 16050.
- B. Product Data:
 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 2. Equipment Nameplate Schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 - c. Schedule format shall match equipment nameplate schedule attached at the end of this section.
 - d. Submit equipment nameplate schedule for approval before engraving nameplates.
 3. Wire Numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.
 4. The CONTRACTOR shall submit samples for each type of Electrical Identification device intended to be provided for this project for review and approval. Samples of the materials and colors proposed for the WORK and application instructions shall be included. Devices shall indicate proposed text sizes, lettering and background coloring and related information.
- C. Record Documents:
 1. Update the circuit/raceway block diagrams to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE

- A. Schedule a pre-installation conference in accordance with Section 16050 in order to clearly define the requirements specified for equipment identification:
 1. Representatives of the CONTRACTOR, OWNER, and ENGINEER shall convene before any major purchases of cable or conductors and before the installation or termination of any cables or conductors.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 16050.

1.08 WARRANTY

- A. Refer to Section 16050.

1.09 SYSTEM START UP

- A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nameplates and Signs:
 - 1. One of the following or equal:
 - a. Brady.
 - b. Seton.
- B. Conductor and Cable Markers:
 - 1. Heat-Shrinkable Tubing:
 - a. One of the following or equal:
 - 1) Raychem.
 - 2) Brady.
 - 3) Thomas & Betts.
 - 4) Kroy.
 - 2. Marker Printer:
 - a. One of the following or equal:
 - 1) Brady XC Plus.
- C. Conduit and Raceway Markers:
 - 1. One of the following or equal:
 - a. Panduit.
 - b. Almetek.

2.02 MATERIALS

- A. Nameplates:
 - 1. General:
 - a. Identification tags shall utilize the OWNER standard numbering system for equipment supplied and installed as part of this project. Identification tags installed for outdoor equipment shall be rated for weatherproof type.
 - b. When identifying a power source for equipment, the tag shall include the source name and circuit or compartment number (i.e., "100MCC0101-4F" or "100IP0101, CKT. #1").
 - c. For all equipment, identification shall include the descriptive name on the first line, the CWS standard tag number on the second line and the power source on the third line (e.g.,

Secondary Clarifier 7 RAS Pump #1
46P1801
Power Source 100MCC0101-4F).
 - d. Text shall be centered on all nameplates and identification devices.
 - 2. Electrical Equipment:
 - a. Disconnect Switches: Each local power disconnect switch and circuit breaker for actuators, instrument transmitters, controllers, and other equipment shall

be identified with a phenolic nameplate. The nameplate shall identify the load served by equipment name and tag number, and the power source.

Nameplates shall be not less than 1 inch high with lettering not smaller than 1/4 inch. Nameplates shall be attached using self-tapping S.S. screws.

- b. Local Control Panels (LCP), Control Stations (CS), and field instruments: Each LCP/CS/Field instrument shall include a nameplate on the enclosure face identifying the panel name and tag number. Include the power source for each panel. Each panel-mounted device (internal and external) shall be identified. Pilot devices shall utilize collar-type, oversize nameplates provided with the pilot devices. Non-pilot devices shall have phenolic nameplates, attached using permanent adhesive. Internal panel devices shall have phenolic identification plates (hand markings not permitted) and shall be attached using permanent adhesive. Wiring and terminal blocks
 - 1) LCP/CS/Field instrument master nameplate shall be not less than 1 inch high with not less than 1/2-inch lettering.
 - 2) External and internal panel devices shall have nameplates not less than 1/2-inch-high with not less than 3/16-inch lettering.
 - 3) Where field instruments do not permit installation of phenolic nameplates, provide a round, stamped, stainless steel nameplate using not less than 1/4-inch-high lettering, neatly fastened by means of stainless-steel wire.

B. Signs:

- 1. Automatic Equipment and High Voltage Signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.

C. Conductor and Cable Markers:

- 1. Machine printed black characters on white tubing.
- 2. 10-point type or larger.

D. Conduit and Raceway Markers:

- 1. 12 GA stainless steel, 3/4-inch by 2-inch minimum.
- 2. Stamped or engraved lettering.
- 3. Minimum 1/4-inch high letters.

2.03 SOURCE QUALITY CONTROL

A. Nameplates:

- 1. Provide all nameplates for control panel operator devices (i.e., pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

PART 4 INSTALLATION

- A. Refer to Section 16050.
- B. Nameplates:
 - 1. Attach nameplates to equipment with self-tapping stainless-steel screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment as specified for each equipment.
 - 2. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the ENGINEER.
- C. Conductor and Cable Markers:
 - 1. Apply all conductor and cable markers before termination.
 - 2. Non Heat-Shrinkable Tubing:
 - a. Tubing shall be sized for the wire and insulation on which it is to be placed.
 - b. Tubing shall be tight on the wire.
 - c. Characters shall face the open panel and shall read from left to right or top to bottom.
 - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
 - e. Identification labels shall be installed at each conductor termination.
 - 3. Conductor numbers shall be named based on the equipment tag of the field device utilizing the electrical power source. The form of the tag shall be 406P1205C2 where '406P1205' represents the equipment designation; 'C' indicated a control cable and 2 is a sequential number developed as part of the circuit design. Cable type designations shall follow the designations listed below:
 - a. C - Control
 - b. S - Signal (below 80 volts AC or DC)
 - c. P - Power
 - d. N - Network (Ethernet, Profibus ...)
- D. Conduit Markers:
 - 1. Furnish and install conduit markers for every conduit in the electrical system or part of the process system. Conduits shall be identified as indicated on the circuit/raceway block diagrams
 - a. Conduit markings shall match the circuit/raceway block diagrams.
 - b. For conduits not shown on circuit/raceway block diagrams, provide conduit markings as described below:
 - 1) Start with a prefix letter that designates its purpose ("C" for control, "P" for power, "S" for Signal, and "PC" for combined power and control), followed by a facility code, followed by a sequence number. e.g., C-100P0101 is a control conduit in the IPS facility for pump 1. P-100P0101 is a power conduit in the IPS facility for pump 1. S-100P0101 is a signal conduit in the IPS facility for pump 1. PC-340FV1301 is a combined power and control conduit in PEPS facility for control valve (Combined circuit allowed per OWNER approval only).

- 2) If the conduit is a continuation or branch of another conduit, the last space is a letter, such as A, B, C, etc.
 - 3) When a single loop network circuit is utilized among equipment, conduit number for coming and leaving the equipment shall be assigned a prefix from and to. e.g. NFR: 100P0101 is a communication network from IPS Facility Pump 1. NTO: 100P0102 is a communication network to IPS Facility Pump 2.
2. Mark Conduits at the Following Locations:
 - a. Each end and every 50 feet for conduits greater than 10 feet in length.
 - b. Where the conduit penetrates a wall or structure.
 - c. Where the conduit emerges from the ground, slab, etc.
 - d. The middle of conduits that are 10 feet or less in length.
 3. Mark conduits after the conduits have been fully painted.
 4. Position conduit markers so that they are easily read from the floor.
 - a.
 5. 12-gauge stainless steel tags 3/4-inch by 2-inch minimum - conduit tags shall be attached to the raceway with Type 316 stainless steel wires.
 6. Mark conduits before construction review by ENGINEER for punch list purposes.
 7. Label intrinsically safe conduits in accordance with the requirements of the National Electrical Code (NEC).
- E. Labeling:
1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to Operations Personnel.
 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, and where the voltage exceeds 600 volts.
 3. Place warning signs on utilization equipment that has more than one source of power. Use warning signs to identify every panel and circuit number of the disconnecting means all external power sources:
 - a. Place warning signs on utilization equipment that has 120 VAC control voltage sources used for interlocking.
 - b. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
 4. Each switch, receptacle and similar device shall include a nameplate indicating the power source and circuit number providing power to the switch or receptacle. For circuits other than 120V, identify the voltage and phase (e.g. 277V, 1Ø or 480V, 3Ø).
 5. Each panelboard shall be identified with a phenolic nameplate. The nameplate shall include the panel name and tag number, voltage, phase, ampere rating and power source. Nameplate shall be 2.25 inches high with 1/2-inch-high lettering and attached using self-tapping stainless-steel screws.
 6. Each manhole, handhole or underground pull box lid shall be clearly identified as "Electric". In addition, include a 2-inch by 6-inch stainless steel identification tag utilizing 1/2-inch lettering. The tag shall include the identification number shown on the drawings, and shall further identify the manhole, handhole or pull box as

“Medium Voltage Power”, “Low Voltage Power”, “Control”, “Signal” or “Communication”, as applicable.

7. Aboveground pull boxes, junction boxes and terminal boxes shall be identified using a stainless-steel tag. Identify the box as “Power”, “Control”, “Signal” or “Fiber Optic” as applicable. Assign unique box numbers in accordance with OWNER standards.

F. Signs:

1. Automatic Equipment and High Voltage Signs:
 - a. Mount permanent warning signs at mechanical equipment that may be started automatically from remote locations. Fasten warning signs with round head stainless steel screws or bolts. Locate and mount warning signs in a suitable manner that is acceptable to the ENGINEER.
2. Provide additional signage in accordance with applicable NEC requirements.

4.01 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the ENGINEER do not meet the ENGINEER’s aesthetic requirements.

4.02 SCHEDULES

- A. Submit nameplate schedules on 11 x 17 inch sheets.

END OF SECTION

SECTION 16080

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUBMITTALS

- A. Informational Submittals:
 - 1. Submit 30 days prior to performing inspections or tests:
 - a. Schedule for performing inspection and tests.
 - b. List of references to be used for each test.
 - c. Sample copy of equipment and materials inspection form(s).
 - d. Sample copy of individual device test form.
 - e. Sample copy of individual system test form.
 - 2. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
 - 3. Operation and Maintenance Data:
 - a. In accordance with Section 01782, Operation and Maintenance Data.
 - b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

1.02 QUALITY ASSURANCE

- A. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.
- B. Test instrument calibration shall be in accordance with NETA ATS.

1.03 SEQUENCING AND SCHEDULING

- A. Perform inspection and electrical tests after equipment listed herein has been installed.
- B. Perform tests with apparatus de-energized whenever feasible.
- C. Inspection and electrical tests on energized equipment shall be:
 - 1. Scheduled with District prior to de-energization.
 - 2. Minimized to avoid extended period of interruption to the operating plant equipment.
- D. Notify District at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS NOT USED

PART 3 EXECUTION

3.01 GENERAL

- A. Perform tests in accordance with requirements of Section 01756, Testing, Training, and Facility Startup.
- B. Tests and inspections shall establish:
 - 1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
 - 2. Installation operates properly.
 - 3. Equipment is suitable for energization.
 - 4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.
- E. Perform inspection and testing in accordance with industry standards, and manufacturer's recommendations.
- F. Adjust mechanisms and moving parts of equipment for free mechanical movement.
- G. Verify nameplate data for conformance to Contract Documents and approved Submittals.
- H. Realign equipment not properly aligned and correct unlevelness.
- I. Properly anchor electrical equipment found to be inadequately anchored.
- J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified.
- K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.
- L. Provide proper lubrication of applicable moving parts.
- M. Inform Engineer of working clearances not in accordance with NFPA 70.
- N. Investigate and repair or replace:
 - 1. Electrical items that fail tests.
 - 2. Active components not operating in accordance with manufacturer's instructions.
 - 3. Damaged electrical equipment.
- O. Electrical Enclosures:
 - 1. Remove foreign material and moisture from enclosure interior.
 - 2. Vacuum and wipe clean enclosure interior.
 - 3. Remove corrosion found on metal surfaces.

4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
 5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
 6. Repair or replace improperly operating latching, locking, or interlocking devices.
 7. Replace missing or damaged hardware.
 8. Finish:
 - a. Provide matching paint and touch up scratches and mars.
 - b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.
- P. Notify the Engineer of fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 NOT USED

3.03 NOT USED

3.04 NOT USED

3.05 NOT USED

3.06 NOT USED

3.07 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

- A. Visual and Mechanical Inspection:
1. Mechanical Connections For:
 - a. Proper lug type for conductor material.
 - b. Proper lug installation.
 - c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 2. Shielded Instrumentation Cables For:
 - a. Proper shield grounding.
 - b. Proper terminations.
 - c. Proper circuit identification.
 3. Control Cables For:
 - a. Proper termination.
 - b. Proper circuit identification.
- B. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.08 NOT USED

3.09 NOT USED

3.10 NOT USED

3.11 NOT USED

3.12 NOT USED

3.13 NOT USED

3.14 NOT USED

3.15 NOT USED

3.16 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Accessible connections to grounding electrodes for proper fit and tightness.
2. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

3.17 NOT USED

3.18 NOT USED

3.19 NOT USED

3.20 NOT USED

3.21 NOT USED

END OF SECTION

SECTION 16123
600LT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes Requirements for:
 - 1. 600-volt class wire and cable.
 - 2. Instrumentation class wire and cable.

1.02 REFERENCES

- A. Refer to Section 16050.
- B. American Society for Testing and Materials (ASTM):
 - 1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B 8 - Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. A167 - Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 4. B263 - Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
- C. Insulated Cable Engineers Association (ICEA):
 - 1. IPCEA S-61-402 for thermoplastic insulated wire and cable for the transmission and distribution of electrical energy.
 - 2. IPCEA S-61-402 for rubber insulated wire and cable for the transmission and distribution of electrical energy.
 - 3. T-29-520 - Conducting Vertical Cable Tray Flame Tests and a Theoretical Heat Input of 210,000 Btu/hour.
 - 4. S-58-679 - Standard for Control Cable Conductor Identification.
- D. National Fire Protection Association (NFPA):
 - 1. Article 70 - National Electrical Code (NEC).
 - 2. Article 72 - National Fire Alarm Code.
 - 3. Article 101 - Life Safety Code.
 - 4. Article 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- E. Federal Specification J-C 30A.
- F. Underwriter's Laboratories Inc., (UL):
 - 1. UL 1277 Subject - Electrical Power and Control Tray Cables with Optional Optical-fiber Members.

2. UL 1063 - Machine-Tool Wires and Cables.
 3. UL 1581 - Reference Standard for Electrical Wires, Cables, and Flexible Cords.
 4. UL-2196 - Tests for Fire Resistive Cables.
 5. UL-1424 - Cables for Power-Limited Fire-Alarm Circuits.
 6. UL-1569 - Metal-Clad Cables.
 7. UL-2225 - Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations.
 8. 13 - Standard for Safety Power-Limited Circuit Cables.
 9. 44 - Standard for Safety Thermoset - Insulated Wires and Cables.
 10. 62 - Standard for Safety Flexible Cord and Fixture Wire.
 11. 486A - Standard for Safety; Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 12. 486C - Splicing Wire Connectors.
 13. 510 - Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
- G. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
1. 48 - Standard Test Procedures and Requirements for Alternating-Current Cable Terminations.
- H. National Electrical Manufacturers' Association (NEMA):
1. CC 1 - Electric Power Connectors for Substations.
 2. WC 55 - Instrumentation Cables and Thermocouple Wire.
 3. WC 70 - Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.

1.03 DEFINITIONS

- A. Refer to Section 16050.
- B. Definitions of terms and other electrical considerations as set forth in the:
1. Insulated Cable Engineering Association (ICEA).
 2. American Society of Testing Materials (ASTM)

1.04 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

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

- B. Product Data:
 - 1. Manufacturer of Wire and Cable.
 - 2. Insulation:
 - a. Type.
 - b. Voltage class.
 - 3. American Wire Gauge size.
 - 4. Conductor material.
 - 5. Pulling compounds.
- C. Shop Drawings:
 - 1. Show splice locations.
- D. Test Reports:
 - 1. Submit test reports for meg-ohm tests.

1.06 QUALITY ASSURANCE

- A. Refer to Section 16050.
- B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 16050.

1.08 WARRANTY

- A. Refer to Section 16050.

1.09 SYSTEM START-UP

- A. Refer to Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the Following or Equal:
 - 1. 600 Volt Class Wire and Cable:
 - a. General Cable.
 - b. Okonite Company.
 - c. Southwire Company.
 - 2. Instrumentation Class Wire and Cable:
 - a. Alpha Wire Company.
 - b. Belden CDT.

- c. General Cable BICC Brand.
- d. Okonite Company.
- e. Rockbestos Surprenant Cable Corporation.
- 3. Network Cables:
 - a. Belden CDT.
 - b. Siemens.
 - c. Lucent.

2.02 MATERIALS

- A. Conductors:
 - 1. Copper per ASTM B 3.
 - 2. Minimum 97 percent conductivity.

2.03 MANUFACTURED UNITS

- A. General:
 - 1. Conductors, include grounding conductors, shall be stranded copper. Solid conductors shall not be permitted. Aluminum conductor wire and cable will not be permitted.
 - 2. Provide new wires and cables manufactured within 1 year of the date of delivery to the site.
 - 3. Permanently mark each wire and cable with the following at 24 inch intervals:
 - a. American Wire Gauge (AWG) size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
 - 4. Identify and mark wire and cable as specified in Section 16075.
- B. 600 Volt Class Wire and Cable:
 - 1. Provide American Wire Gauge (AWG) or kcmil sizes as indicated on the Drawings:
 - a. When not indicated on the Drawings, size wire as follows:
 - 1) In accordance with the National Electrical Code:
 - a) Use 75-degree Celsius ampacity ratings.
 - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide Number 12 AWG minimum for power conductors.
 - 3) Provide Number 14 AWG minimum for control conductors.
 - 2. Provide Class B stranding per ASTM B 8:
 - a. Provide Class C stranding where extra flexibility is required.
 - 3. Insulation:
 - a. XHHW-2.
 - b. 90-degree Celsius rating in wet or dry locations.
 - 4. Conductors for feeders shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or

combinations of such loads, and where the maximum total voltage drop on the both feeders and branch circuits to farthest connected load does not exceed 5 percent.

5. Multi-conductor Cables:

a. Type 1 – Multi-conductor Control Cable:

- 1) Conductors:
 - a) No. 14 AWG, seven -strand copper, tray cable rated.
 - b) Insulation: 30-mil PVC.
 - c) UL 1581 listed as Type XHHW-2 rated VW-1.
 - d) Conductor group bound with spiral wrap of barrier type.
 - e) Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
- 2) Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.
- 3) Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.50	45
6	0.53	45
9	0.64	60
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

b. Type 2, Multi-conductor Power Cable:

- 1) Conductors:
 - a) Class B stranded, coated copper.
 - b) Insulation: Chemically cross-linked ethylene-propylene with Hypalon jacket.
 - c) UL 1581 listed as Type EPR, rated VW-1.
 - d) Color Code:
 - (1) Conductors, size No. 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
 - (2) Conductors, size No. 6 AWG and larger, ICEA S-58-679, Method Y.
- 2) Cable pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.

3) Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60
8	10	2	0.62	60
		3	0.66	60
		4	0.72	60
6	8	3	0.74	60
		4	0.81	60
4	6	3	0.88	60
		4	0.97	80
2	6	3	1.01	80
		4	1.11	80
1/0	6	3	1.22	80
		4	1.35	80
2/0	4	3	1.32	80
		4	1.46	80
4/0	4	3	1.56	80
		4	1.78	110

6. Instrumentation Cables:

- a. Type 3, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log application is meeting NEMA WC 55 requirements.
 - 1) Outer Jacket: 45-mil nominal thickness.
 - 2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 - 3) Dimension: 0.31-inch nominal OD.
 - 4) Conductors:
 - a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b) 20 AWG, seven-strand tinned copper drain wire.
 - c) Insulation: 15-mil nominal PVC.
 - d) Jacket: 4-mil nominal nylon.
 - e) Color Code: Pair conductors black and white.
- b. Type 4, No. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, design for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
 - 1) Outer Jacket: 45-min nominal.
 - 2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 - 3) Dimension: 0.32-inch nominal OD.

- 4) Conductors:
 - a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b) 20 AWG, seven-strand, tinned copper drain wire.
 - c) Insulation: 15-mil nominal PVC.
 - d) Jacket: 4-mil nylon.
 - e) Color Code: Triad conductors black, red, and white.
- c. Type 5, No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.
 - 1) Conductors:
 - a) Bare soft annealed copper, Class B, seven-strand concentric, in Accordance with ASTM B8.
 - b) Tinned copper drain wires.
 - c) Pair drain wire size AWG 20, group drain wire size AWG 18.
 - d) Insulation: 15-mil PVC.
 - e) Jacket: 4-mil nylon.
 - f) Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
 - g) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
 - 2) Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
 - 3) Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

- d. Type 6, No. 16 AWG, Solid Chromel +Alumel, Shielded Pair, Type KX Thermocouple Extension Cable: 300V, Yellow FEP Outer Jacket, UL listed.

C. Network Cables:

1. Type 11, Category 6 (CAT 6)
 - a. Conductors:
 - 1) 24 AWG solid bare copper conductors.
 - b. Insulation:
 - 2) Polyolefin.
 - 3) 4 non-bonded twisted pair cables formed into a cable core.
 - c. Color Code:
 - 4) Pair 1: White/Blue Stripe and Blue
 - 5) Pair 2: White/Orange Stripe and Orange
 - 6) Pair 3: White/Green Stripe and Green

- 7) Pair 4: White/Brown Stripe and Brown
- d. Outer Jacket:
 - 8) PVC with ripcord.
- e. Electrical Characteristics:
 - 9) Frequency Range: 0.772-100 MHz.
 - 10) Attenuation: 32.1dB/100m.
 - 11) Near-End Crosstalk (NEXT): 39.3 dB.
 - 12) Power Sum NEXT: 37.3 dB.
 - 13) Attenuation to Crosstalk Ratio: 7.2 dB.
 - 14) Power Sum Attenuation to Crosstalk Ratio: 5.3 dB/100m.
 - 15) Equal Level Far-End Crosstalk (ELFEXT): 22.8 dB.
 - 16) Power-Sum ELFEXT: 19.8 dB/100m.
 - 17) Return Loss: 17.3 dB.
 - 18) Propagation Delay: 537 ns/100m.
 - 19) Delay Skew: 45 ns/100m.
 - 20) Propagation Delay (Skew), max: 2.5 ns/100m
- b. Terminate CAT 6 cables in an 8P8C T568B fashion.

2.04 ACCESSORIES

- A. Tape:
 - 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
 - 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
- B. Connectors and Terminations:
 - 1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
 - 2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
 - 3. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with setscrew in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturer: 3M Co.
- C. Cable Lugs:
 - 1. In accordance with NEMA CC 1.
 - 2. Rated 600 volts of same material as conductor metal.
 - 3. Insulated, Locking-Fork, Compression Lugs:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.

- c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) ILSCO; ILSCONS.
- 4. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy, Hydent.
 - 3) ILSCO.
- 5. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
- D. Cable Ties:
 - 1. Nylon, adjustable, self-locking, and reusable.
 - 2. Manufacturer and Product: Thomas & Betts; TY-RAP.
 - 3. Cable ties installed outdoors shall be UV resistant and rated for use in direct sunlight.
- E. Heat Shrinkable Insulation:
 - 1. Thermally stabilized, cross-linked polyolefin.
 - 2. Manufacturer and Product: Thomas & Betts; SHRINK-KON.
- F. Pulling Compound:
 - 1. Nontoxic, noncorrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.
 - 2. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
 - 3. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
 - 4. Manufacturers and Products:
 - a. Polywater, Inc.
 - b. Cable Grip Co.

2.05 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall comply with the applicable requirement of ICEA Publication No. S-68-516.
- B. Test in accordance with the requirements of UL 44 and 854 Standards.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 16050.
- B. Color Coding:
 - 1. Color coding shall be consistent throughout the facility.
 - 2. The following color code shall be followed for all 240/120 Volt and 208/120 Volt systems:
 - a. Phase A - black.
 - b. Phase B - red.
 - c. Phase C - blue.
 - d. Single Phase System - black for one hot leg, red for the other.
 - e. Neutral - white.
 - f. High Phase or Wild Leg - orange.
 - g. Equipment Ground - green.
 - 3. The following color code shall be followed for all 480/277 Volt systems:
 - a. Phase A - brown.
 - b. Phase B - orange.
 - c. Phase C - yellow.
 - d. Neutral - gray.
 - e. Equipment Ground - green.
 - 4. The following color code shall be followed for all 120 VAC control wiring:
 - a. Power - red.
 - b. Neutral - white.
 - 5. The following color code shall be followed for all general purpose DC control circuits:
 - a. Negative - white/blue stripe.
 - b. Positive - blue.
 - 6. The following color code shall be followed for all signal (4-20mA or 1-5VDC) circuits:
 - a. Negative - black.
 - b. Positive - white.
 - 7. Switch legs shall be violet. 3-way switch runners shall be pink.
 - 8. Wires in intrinsically safe circuits shall be light blue.
 - 9. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
 - 1. Install wires only in approved raceways.
 - 2. Do not Install wire:
 - a. In incomplete conduit runs.
 - b. Until after the concrete work and plastering is completed.

- D. Properly coat wires and cables with pulling compound before pulling into conduits and prevent mechanical damage to conductors during installation:
 - 1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal as recommended by cable manufacturer.
 - f. Do not use oil, grease or similar substances.
- E. Cable Pulling:
 - 1. For cables Number 1 AWG and smaller, install cables by hand.
 - 2. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
 - 3. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the ENGINEER may, at his discretion, require replacement of the cable.
 - 4. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
 - 5. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
 - a. Make splices in manholes or pull boxes only.
 - b. Leave sufficient slack to make proper connections.
- F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.
- G. Install and terminate all wire in accordance with manufacturer's recommendations.
- H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install all wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.
- I. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head:
 - 1. Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.
 - 2. Do not use crimp lugs on solid wire.
- J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:

1. Use ring type lugs if box lugs are not available on the equipment.
- K. Splices:
1. Provide continuous circuits from origin to termination whenever possible.
 - a. Obtain ENGINEER's approval prior to making any splices.
 2. Lighting and receptacle circuit conductors may be spliced without prior approval from the ENGINEER.
 3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
 - a. Refer to Section 16050 for box NEMA rating requirements.
 - b. Make splices in labeled junction boxes for power conductors.
 - c. Make splices for control and instrument conductors in terminal boxes:
 - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
 4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
 5. Clearly label junction and terminal boxes containing splices with the word "SPICE."
 6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
 7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
 - a. In NEMA 4 or NEMA 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
 8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
 - a) A heat shrink insulating system listed for submersible applications.
 - b) Or an epoxy resin splicing kit.
- L. Apply circuit and wire markers to all wires as described below:
1. Circuit Identification Location: Identify power, instrumentation, and control conductor circuits, using circuit name as described below, at each termination and in accessible locations such as manholes, hand-holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
 2. Circuit Name:
 - a. Assign circuit name based on device or equipment at load end of circuit as indicated on the Drawings.
 - b. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
 3. Method:
 - a. Conductors No. 3 AWG and Smaller: Identify with sleeves or heat bond markers.
 - b. Taped-on markers or tags relying on adhesives not permitted.
 - c. Cables and Conductors No. 2 and Larger:
 - 1) Identify with marker plates; or
 - 2) Tie-on cable marker tags.
 - 3) Attach with nylon tie cord.

M. Instrumentation Class Cable:

1. Install instrumentation class cables in separate raceway systems from power cables:
 - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
 - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
3. Refer to Section 16050 for shield grounding requirements.

N. Signal Cable:

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

O. Submersible cable in wet wells:

1. Provide Kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

P. Wiring Allowances:

1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16050.

B. LAN Cable Testing:

1. Test plan and witnessing:
 - a. Obtain ENGINEER'S approval for the test procedures as part of the submittal process.
 - b. Arrange for the ENGINEER to witness all testing.
2. Submit a request for witness 15 days (minimum) before the proposed test date.
3. Pre-Testing:
 - a. Test individual cables before installation:
 - 1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
 - 2) Before the cable is installed, verify that the cable conforms to the Manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.

- 3) The test shall be fully documented and the results submitted to the ENGINEER, including a hard copy of all traces, before placement of the cable.
 - 4) The ENGINEER shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the ENGINEER.
4. Test Equipment:
- a. LAN Certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
 - 1) Near End Cross Talk.
 - 2) Attenuation.
 - 3) Equal Level Far End Cross Talk.
 - 4) Return Loss.
 - 5) Ambient Noise.
 - 6) Effective Cable Length.
 - 7) Propagation Delay.
 - 8) Continuity/Loop Resistance.
 - b. LAN certification test equipment shall be able to store and produce plots of the test results.
 - c. Manufacturers: One of the following:
 - 1) Agilent Technologies, WireScope 350.
 - 2) Approved equal.
- C. Grounding:
1. Refer to Section 16060.

3.03 PROTECTION

- A. Refer to Section 16050.

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Metallic conduits.
 - 2. Nonmetallic conduits.
 - 3. Conduit bodies.
 - 4. Conduit fittings and accessories.
 - 5. Conduit installation.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16070 - Hangers and Supports.
 - d. Section 16075 - Electrical Identification.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. American National Standards Institute (ANSI):
 - 1. C80.1 - Electrical Rigid Steel Conduit.
 - 2. C80.3 - Steel Electrical Metallic Tubing.
 - 3. C80.5 - Electrical Rigid Aluminum Conduit.
 - 4. C80.6 - Electrical Intermediate Metal Conduit.
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
 - 3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - 4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
 - 5. TC13 - Electrical Nonmetallic Tubing.
 - 6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

- D. Underwriters Laboratories (UL):
1. 1 - Standard for Flexible Metal Conduit.
 2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
 3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
 4. 360 - Standard for Liquid-Tight Flexible Steel Conduit.

651 - STANDARD FOR SCHEDULE 40 AND 80 RIGID PVC CONDUIT AND FITTINGS.

651B - STANDARD FOR CONTINUOUS LENGTH HDPE CONDUIT.

797 - STANDARD FOR ELECTRICAL METALLIC TUBING - STEEL.

1242 - STANDARD FOR ELECTRICAL INTERMEDIATE METAL CONDUIT - STEEL.

1653 - STANDARD FOR ELECTRICAL NONMETALLIC TUBING.

1660 - STANDARD FOR LIQUID-TIGHT FLEXIBLE NONMETALLIC CONDUIT.

1684 - STANDARD FOR REINFORCED THERMOSETTING RESIN CONDUIT (RTRC) AND FITTINGS.

DEFINITIONS

AS SPECIFIED IN SECTION 16050.

SPECIFIC DEFINITIONS AND ABBREVIATIONS:

CONDUIT BODIES: A SEPARATE PORTION OF A CONDUIT SYSTEM THAT PROVIDES ACCESS THROUGH A REMOVABLE COVER TO THE INTERIOR OF THE SYSTEM AT A JUNCTION OF 2 OR MORE CONDUIT SECTIONS. INCLUDES, BUT NOT LIMITED TO: SHAPES C, E, LB, T, X, ETC.

CONDUIT FITTING: AN ACCESSORY THAT SERVES PRIMARILY A MECHANICAL PURPOSE. INCLUDES, BUT NOT LIMITED TO: BUSHINGS, LOCKNUTS, HUBS, COUPLINGS, REDUCERS, ETC.

GRC: GALVANIZED RIGID STEEL CONDUIT.

PCS: PVC COATED RIGID STEEL CONDUIT.

PVC: POLYVINYL CHLORIDE RIGID NONMETALLIC CONDUIT.

SLT: SEAL-TIGHT - LIQUID-TIGHT FLEXIBLE CONDUIT.

EFLX: EXPLOSION PROOF FLEXIBLE CONDUIT.

NPT: NATIONAL PIPE THREAD.

SYSTEM DESCRIPTION

- E. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.03 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
 - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
- C. Certifications:
 - 1. Furnish PVC-coated conduit manufacturer's certification for each installer.
- D. Record Documents:
 - 1. Incorporate all changes in conduit routing on electrical plan drawings.
 - 2. Dimension underground and concealed conduits from building lines.
 - 3. Furnish hard copy drawings and electronic files in AutoCAD format Version: 2018 .
- E. Installation drawings: Installation drawings, including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.04 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
- C. Every installer of PCA or PCS conduits shall be certified by the manufacturer for installation of the conduit.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.
- B. Do not expose type PVC to direct sunlight.
- C. Do not store conduit in direct contact with the ground.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.07 SEQUENCING

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
 - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.08 WARRANTY

- A. As specified in Section 16050.

1.09 SYSTEM START-UP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Galvanized rigid steel conduit:
 - 1. One of the following or equal:
 - a. Western Tube and Conduit.
 - b. Allied Tube and Conduit.
 - c. Wheatland Tube Co.
- B. Polyvinyl chloride coated rigid steel conduit:
 - 1. One of the following or equal:
 - a. Robroy Industries.
 - b. Ocal, Inc.
- C. Seal-tight liquid-tight flexible conduit:
 - 1. One of the following or equal:
 - a. Southwire.
 - b. AFC Cable Systems.
 - c. Electri-flex.
 - d. Anaconda.
- D. Explosion proof flexible conduit:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse Hinds.
 - c. Hubbell Killark.
- E. Rigid nonmetallic polyvinyl chloride conduit:
 - 1. One of the following or equal:
 - a. Carlon.
 - b. Cantex.
 - c. Triangle Conduit and Cable.
- F. Conduit bodies:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney.
 - d. Ocal.
 - e. Robroy.
 - f. Carlon.

G. Galvanized rigid steel conduit expansion fittings:

1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney.

H. Conduit sleeve:

1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney.

I. Conduit seals:

1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z / Gedney.

J. Conduit hangers and supports:

1. As specified in Section 16070.

K. Conduit through wall and floor seals:

1. The following or equal:
 - a. O-Z/Gedney:
 - 1) Type "WSK".
 - 2) Type "CSM".

2.02 COMPONENTS

A. GRC:

1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
 - a. UL-6.
 - b. ANSI C80.1.

B. PCS:

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
2. Coated conduit NEMA Standard RN-1:
 - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory bonded PVC jacket:
 - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.

- b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.
 - c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
 - d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
 - 1) Confirm bond with certified test results.
 - 4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
 - a. Nominal thickness of 0.002 inch.
 - b. Conduit having areas with thin or no coating are not acceptable.
 - c. All threads shall be coated with urethane.
 - 5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
 - 6. PCS conduit bodies and fittings:
 - a. Malleable iron.
 - b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
 - c. The PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
 - d. 0.002 inch interior urethane coating.
 - e. Utilize the PVC coating as an integral part of the gasket design.
 - f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.
 - g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
 - 1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 - 2) The sleeve shall provide a vapor and moisture tight seal at every connection.
- C. EFLX:
- 1. Suitable for the hazardous Class and Group where installed:
 - a. As specified in Section 16050.
 - 2. Metallic braid shall provide continuous electrical path.
 - 3. Stainless steel construction.
 - 4. Provide fittings and unions as required for the installation.
- D. PVC:
- 1. Extruded from virgin polyvinyl chloride compound:
 - a. Schedule 40 unless otherwise specified.
 - b. Schedule 80 extra heavy wall where specified.
 - 2. Rated for 90 degrees Celsius conductors or cable.
 - 3. Rated for use in direct sunlight. Conduit bodies:
 - 4. Material consistent with conduit type:
 - a. Malleable iron bodies and covers when used with type GRC conduit.
 - b. Cast aluminum bodies and covers when used with type RAC.

- c. PVC bodies and covers when used with type PVC.
- d. PVC-coated malleable iron bodies and covers when used with type PCS.
- e. PVC-coated copper-free cast aluminum bodies and covers when used with type PCA.
- f. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.
- 5. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
 - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire bending space.
- 6. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.03 ACCESSORIES

- A. Connectors and fittings:
 - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
 - 1. Construction:
 - a. Malleable iron or zinc plated steel when used with steel conduit.
 - b. Aluminum when used with aluminum conduit.
 - c. Positive metallic conduit end stop.
 - d. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
 - e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees Celsius rated non-combustible thermosetting phenolic.
- C. Insulated grounding bushings:
 - 1. Construction:
 - a. Malleable iron or steel, zinc plated, with a positive metallic end stop.
 - b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
 - c. Tin plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions (Erickson Couplings):
 - 1. Construction:
 - a. Malleable iron for use with steel conduit.
 - b. Aluminum for use with aluminum conduit.
 - c. Concrete tight, 3-piece construction.
 - d. Rated for Class I Division 1 Group D in hazardous areas.
- E. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
 - 1. Construction:
 - a. Insulated throat.
 - b. PVC coated when used in corrosive areas.
 - c. Bonding locknut.
 - d. Recessed neoprene O-ring to assure watertight and dust-tight connector.
 - e. One half (1/2)-inch through 1-1/4-inch steel zinc electroplated.
 - f. One and one half (1-1/2)-inch through 6-inch malleable iron zinc plated.

- g. Aluminum with aluminum conduit.
 - 2. Usage:
 - a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- F. Sealing fittings:
 - 1. Construction:
 - a. 40 percent wire fill capacity.
 - b. PVC-coated when used in corrosive areas.
 - c. Malleable ductile iron with steel conduit.
 - d. Aluminum with aluminum conduit.
 - e. Crouse-Hinds Type EYD where drains are required.
 - f. Crouse-Hinds Type EYS where drains are not required.
 - g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; Class II, Divisions 1 and 2; Groups E, F, and G.
 - 2. Sealing compound:
 - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
 - b. Approved for the conditions and use.
 - 1) Not affected by surrounding atmosphere or liquids.
 - c. Melting point shall be 200 degrees Fahrenheit minimum.
- G. PVC fittings:
 - 1. Shall include the following:
 - a. Couplings.
 - b. Terminal adapters.
 - c. Female adapters.
 - d. Caps.
 - e. Reducer bushings.
 - f. Duct couplings.
 - g. End bells.
 - h. Expansion couplings.
 - i. Duct couplings 5 degree.
 - j. C - pull fittings.
 - k. E - pull fittings.
 - l. LB - pull fittings.
 - m. LL - pull fittings.
 - n. LR - pull fittings.
 - o. T - pull fittings.
 - p. X - pull fittings.
 - q. Service entrance caps.
 - 2. Materials:
 - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. All metal hardware shall be stainless steel.
- H. Through wall and floor seals:
 - 1. Materials:
 - a. Body: casting of malleable or ductile iron with a hot-dip galvanized finish.
 - b. Grommet: neoprene.
 - c. Pressure rings: PVC coated steel.
 - d. Disc material: PVC coated steel.

- e. Aluminum when used with conduit type RAC.
- I. Expansion/deflection couplings:
 - 1. Use to compensate for movement in any directions between 2 conduit ends that they connect.
 - 2. Shall allow movement of 3/4 inch from the normal in all directions.
 - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 - 4. Constructed to maintain electrical continuity of the conduit system.
 - 5. Materials:
 - a. End couplings: Bronze or galvanized ductile iron.
 - b. Sleeve: Neoprene.
 - c. Bands: Stainless steel.
 - d. Bonding jumper: Tinned copper braid.
- J. Expansion couplings:
 - 1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
 - 2. Constructed to maintain electrical continuity of the conduit system.
 - 3. Materials:
 - a. Head: Malleable or ductile iron.
 - b. Sleeve: Steel.
 - c. Insulating bushing: Phenolic.
 - d. Finish: Hot-dip galvanized.
 - e. Aluminum when used with conduit type RAC.
- K. Conduit markers:
 - 1. As specified in Section 16075.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 16050.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. General:
 - 1. Conduit routing:
 - a. The Electrical Drawings are diagrammatic in nature:
 - 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
 - 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
 - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
 - b) Make changes in conduit routing due to the relocation of equipment.

- 3) The Electrical Drawings do not indicate all required junction boxes and pull boxes:
 - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
 - (1) To meet cable manufacturer's pulling tension requirements.
 - (2) To limit total conduit bends between pull locations.
 - b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
 - b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the circuit/raceway block diagrams without the express written approval or direction by the Engineer:
 - 1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
 - 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
 - 3) Incorporate any deviations on the Record Documents.
 - c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on Record Drawings.
2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
 3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
 - a. Clearances of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
 - b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
 - d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
 4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
 - a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
 5. Do not install 1 inch or larger conduits in or through structural members unless approved by the Engineer.
 6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
 - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
 - b. Make changes in direction with long radius bends or with conduit bodies.
 7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.
 8. Route all exposed conduit to preserve headroom, access space and work space and to prevent tripping hazards and clearance problems:
 - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment removal hatches.

- b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.
 - 9. Conduit may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:
 - a. Refer to the typical details for conduit spacing and size requirements.
 - 10. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, etc.
 - 11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
 - 12. Install conduit through wall and floor seals where indicated on the Drawings.
 - 13. For existing and new 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
 - a. Remove and replace conduits through which mandrel will not pass.
 - 14. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
 - 15. Install complete conduit systems before conductors are installed.
 - 16. Provide metallic conduits terminating in transformer, switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
 - 17. Underground and embedded conduits:
 - a. Make underground conduit size transitions at hand-holes and manholes.
 - b. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and hand-holes.
- C. Conduit usage :
- 1. Exposed conduits:
 - a. Rigid conduit:
 - 1) Install the rigid conduit type for each location as specified in Section 16050.
 - 2) Minimum size: 3/4-inch.
 - b. Flexible conduit:
 - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:
 - a) Use type EFLX in Class I Division 1 locations.
 - b) Use type FLX in finished areas.
 - 2) Minimum size: 3/4-inch:
 - a) 1/2 when required for connection to instruments.
 - 3) Maximum length:

Conduit Trade Size	Flexible Conduit Length (in)
3/4	18
1	18
1-1/4	18

Conduit Trade Size	Flexible Conduit Length (in)
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

2. Concrete encased and embedded conduits:
 - a. Type PVC Schedule 40 and PVC coated rigid metallic conduit as specified below:
 - 1) Use Type PCS in underground and embedded installation as follows:
 - a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
 - b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished floor.
 - c) For any and all bends where the total deflection is greater than 45 degrees.
 - b. Minimum size:
 - 1) 2 inches in duct banks unless otherwise indicated on the Drawings.
 - 2) 1 inch for in slab conduits unless otherwise indicated on the Drawings.
 3. Direct buried and sand bedded duct bank conduits:
 - a. Type PCS.
 - b. Minimum size: 1 inch.
 4. PVC coated rigid metallic conduit:
 - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
 5. GRC:
 - a. Conduit shall be cut square and reamed before threading.
 6. PVC:
 - a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
 - b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.
 - 1) Use a locknut on the inside of the box to tighten the adapter to the box.
 - c. Route conduit to afford it the maximum physical protection.
 - 1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
 - a) Use Schedule 80 where exposed runs may be subject to physical damage.
- D. Conduit joints and bends:
1. General:
 - a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA Type 4 or NEMA Type 4X locations, make joints liquid-tight.
 - b. Keep bends and offsets in conduit runs to an absolute minimum.
 - c. All bends shall be symmetrical.
 - d. The following conduit systems shall use large radius sweep elbows:
 - 1) Underground conduits.

- 2) Conduits containing medium voltage cables.
 - 3) Conduits containing shielded cables.
 - 4) Conduits containing fiber optic cables.
 - e. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
 - f. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
 - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
 - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
 - b) For the serving utilities, make bends to meet their requirements.
 - g. Replace all deformed, flattened, or kinked conduit.
 - 2. Threaded conduit:
 - a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
 - b. Thoroughly ream conduit after threads have been cut to remove burrs.
 - c. Use bushings or conduit fittings at conduit terminations.
 - d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar" or CRC "Zinc It."
 - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
 - 1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit.
 - 2) Apply to the male threads and tighten joints securely.
 - 3) Clean excess sealant from exposed threads after assembly.
 - f. Securely tighten all threaded connections.
 - g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
 - 3. PVC:
 - a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.
 - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends:
 - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.
- E. Conduit sealing and drainage:
- 1. Conduit drainage and sealing other than required for hazardous and classified areas:
 - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enter buildings, switchgear, control panels, lighting panel-boards, and other similar enclosures.
 - b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.

- c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
 - 1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
 - d. Provide conduit seals similar to O/Z Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
 - e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, or equal.
 - 2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pull-boxes, or low points of conduit.
- F. Conduit supports:
 - 1. General:
 - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
 - 1) As specified in Section 16070.
 - 2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050.
 - b. Support conduit at the intervals required by the NEC.
 - c. Perforated strap and plumbers tape are not acceptable for conduit supports.
 - 2. Conduit on concrete or masonry:
 - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
 - b. Use preset inserts in concrete when possible.
 - c. Use pipe spacers (clamp backs) in wet locations.
 - d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
 - 3. Conduit on metal decking:
 - a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet metal screws. Fully or partially hammer-driven screws are not acceptable.
 - 4. Suspended conduit:
 - a. Use malleable iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
 - b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
 - 5. Supports at structural steel members:
 - a. Use beam clamps.
 - b. Drilling or welding may be used only as specified or with approval of the Engineer.
 - 6. PCS systems:
 - a. Provide right angle beam clamps and U bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC encapsulated nuts that cover the exposed portions of the threads.
 - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

G. Expansion or expansion/deflection fittings:

1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.
 - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit (PCS, PCA, GRC and RAC) provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
 - a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
 - b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

H. Empty conduits:

1. Provide a polyethylene rope rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Provide one empty 3/4-inch conduit for each four spare unused circuits or spaces of each flush mounted branch circuit panel-board. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.
3. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.

I. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
 - a. Running threads and thread-less couplings are not allowed.
3. Replace any conduit installed that the Engineer determines does not meet the requirements of this Specification.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electrical underground duct banks.
 - 2. Duct spacing and terminations.
 - 3. Steel reinforcing of concrete.
 - 4. Excavation and patching.
 - 5. Coordination with other underground utilities.
 - 6. Concrete.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16130 - Conduits.
 - c. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.

- B. Product data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Pull line.
- C. Shop drawings:
 - 1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.
- B. Field conditions and related requirements:
 - 1. Underground water table may be near or above the location of new duct banks.
 - 2. Include cost for necessary dewatering, and cleaning equipment to perform work in underground duct banks, pull boxes and manholes, before installation.

1.09 WARRANTY

- A. As specified in Section 16050.

1.10 SYSTEM START-UP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Conduit spacers:
 - 1. One of the following or equal:
 - a. Carlon Snap-Loc.
 - b. Cantex.
 - c. Osburn Associates, Inc.
- B. Detectable underground marking tape:
 - 1. One of the following or equal:
 - a. Blackburn Manufacturing Company.
 - b. Pro-Line Safety Products.
 - c. Panduit.

- C. Pull line:
 - 1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.

2.02 MATERIALS

- A. Provide conduit as specified in Section 16130:
 - 1. Use duct suitable for use with 90-degree Celsius rated conductors.
- B. Provide reinforcing steel as specified in Section 03200:
 - 1. Provide minimum Number 4 reinforcing steel.

2.03 MANUFACTURED UNITS

- A. Conduit spacers:
 - 1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
 - 2. Saddle type.
 - 3. Non-metallic, non-corrosive, non-conductive.
 - 4. Interlocking type:
 - a. Vertical interlocking.
 - b. Horizontal interlocking.
 - 5. Suitable for concrete encasement.
 - 6. Molded-in rebar holder.
 - 7. Accommodates 2-inch through 6-inch conduit sizes.
 - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
 - 1. Minimum 1/4-inch wide, flat design.
 - 2. Polyester.
 - 3. Minimum pulling strength 1,200 pounds.
 - 4. Sequential footage markings.
- C. Detectable marking tape:
 - 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
 - 2. Aluminum core laminated between polyethylene film.
 - 3. Six-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."

2.04 MIXES

- A. Concrete mix requirements as specified in Civil Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Duct banks:
 - 1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
 - 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
 - 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system and every 20 feet to steel reinforcing bar.
 - 5. Install underground ducts to be self-draining:
 - a. Slope duct banks away from buildings to manholes.
 - b. Slope duct banks uniformly from manholes to pull boxes or both ways from high points between manholes.
 - c. Slope a minimum of 1/4 inch per 10 feet.
 - 6. Where new duct banks join to existing manholes make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
 - 7. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- C. Trenching:
 - 1. Trench must be uniformly graded with the bottom, rock free and covered with select material.
 - 2. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 - 3. Avoid damaging existing ducts, conduits, cables, and other utilities.
- D. Duct spacing:
 - 1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 1.5 inches:
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 - 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:

- 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 3. Spacers shall not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- E. Concrete:
 1. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
 - a. Tie wire shall not act as a substitute for spacers.
 2. Install minimum 3-inch cover around conduit and rebar.
 3. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
 4. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
- F. Marking tape:
 1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.
- G. For conduit installations beneath building slabs:
 1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
 - a. Concrete for encasement under building slabs need not be colored red.
 - b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.
 - c. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
 - d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.
- H. Restore all surfaces to their original condition as specified in Civil Drawings, unless otherwise specified.
- I. Marking piers:
 1. Provide permanent concrete cylinder marking piers, on grade, centered on duct bank and located at every bend in duct bank or wherever duct bank enters a building, vault, or other structure:
 - a. Provide a cylinder, 6 inches in diameter:
 - 1) Top of cylinder 1/2 inch below the top of finished grade.
 - b. Provide a 3-inch high "E" embossed in top of cylinder:
 - 1) Minimum of 2 inches deep.
 - c. Provide 2-inch arrows embossed in top of cylinder showing the direction of the duct bank:
 - 1) Minimum of 2 inches deep.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 CLEANING

- A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.04 PROTECTION

- A. As specified in Section 16050.
- B. Provide shoring and pumping to protect the excavation and safety of workers.
- C. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Device boxes.
 - 2. Raceway system boxes.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. A 47 - Standard Specification for Ferritic Malleable Iron Castings.
 - 2. D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 - 3. D 495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
 - 4. D 570 - Standard Test Method for Water Absorption of Plastics.
 - 5. D 648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
 - 6. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 7. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- C. Joint Industry Conference (JIC).
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

- A. As specified in Section 16050.
- B. Specific definitions:
 - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
 - 2. Raceway system boxes: Boxes that are used for wire and cable pull-boxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

- A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pull-boxes for use in the raceway systems, etc.
- B. Provide boxes and conduit bodies as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Manufacturer.
 - 2. Materials.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - e. NEMA rating.
 - 4. Conduit entry locations.
 - 5. Catalog cut sheets.
 - 6. Installation instructions.
- C. Shop drawings:
 - 1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Regulatory requirements:
 - 1. Outlet boxes shall comply with all applicable standards of:
 - a. JIC.
 - b. NEC.
 - c. NEMA.
 - d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING

- A. As specified in Section 16050.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Pressed steel boxes:
 - a. Steel City.
 - b. Appleton.
 - c. Crouse - Hinds.
 - d. Thomas & Betts.
 - 2. Plastic coated steel boxes:
 - a. Rob Roy.
 - b. OCAL.
 - 3. Cast device boxes:
 - a. Appleton.
 - b. Crouse - Hinds.
 - c. OZ/Gedney.
 - 4. Formed steel enclosures:
 - a. Hoffman.
 - b. Thomas and Betts.
 - c. Stahlin.
 - d. Rittal.
 - 5. Stainless steel enclosures:
 - a. Hoffman.
 - b. Stahlin.
 - c. Rittal.
 - 6. Pressed steel boxes and concrete boxes:
 - a. Appleton.
 - b. Steel City.

- c. Cooper/Crouse Hinds.
- d. OZ Gedney.

2.02 MANUFACTURED UNITS

- A. Pressed steel boxes:
 - 1. One-piece galvanized pressed steel.
 - 2. Knockout type boxes.
 - 3. Minimum size 4-inch square by 2-1/8-inch deep.
- B. Concrete boxes:
 - 1. For outlets and pull boxes in concrete construction.
 - 2. Pressed steel or cast construction, concrete tight.
 - 3. Knockout sizes range from 1/2 inch to 1 inch.
 - 4. Depth as needed.
 - 5. Types:
 - a. Four-inch octagon.
 - b. Four-inch octagon ceiling boxes with hanging bars.
 - c. Gangable masonry boxes:
 - 1) 3-1/2-inch deep, 3-3/4-inch high, length as required:
 - a) 2-1/2-inch deep boxes may be used where wall thickness precludes the use of the deeper boxes.
 - 2) With partitions as needed.
- C. Threaded-hub boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Tapered threaded hubs with integral bushing.
 - 2. Aluminum (copper free) boxes:
 - a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
 - 3. Malleable iron boxes:
 - a. Conforming to ASTM A 47 Grade 32510.
- D. Plastic coated threaded-hub boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
 - f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
 - g. With pressure sealing sleeve to protect the connection with conduit.

E. Formed steel enclosures:

1. Steel:
 - a. NEMA Type 12.
 - b. Fabricated from 14-gauge steel, minimum.
 - c. All seams continuously welded ground smooth.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight, dust-tight, oil-tight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
 - 2) White electrostatically applied polyester powder mounting plate.
 - j. Heavy gauge steel external mounting brackets when surface mounted.
2. Stainless steel:
 - a. NEMA Type 4X:
 - 1) Boxes in locations subject to flooding or temporary submersion:
 - a) NEMA Type 6.
 - b. Fabricated from 14-gauge Type 316 stainless steel.
 - c. All seams continuously welded.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) Brushed.
 - j. Stainless steel external mounting brackets when surface mounted.

F. Cast iron junction boxes:

1. NEMA Type 4.
2. Recessed cover boxes.
3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
4. Designed for flush mounting in walls or floors:
 - a. Can be surface mounted using mounting lugs.

5. Construction:
 - a. Cast iron box.
 - b. Covers:
 - 1) Checkered plate covers suitable for foot traffic.
 - 2) When used in areas subject to vehicular traffic H-20 loading.
 - c. Hot dip galvanized.
 - d. Neoprene gasket.
 - e. Stainless steel screw covers.

2.03 ACCESSORIES

- A. Fasteners:
 1. Electroplated or stainless steel in boxes with wiring devices.
 2. Screws, nuts, bolts, and other threaded fasteners:
 - a. Stainless steel.
- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:
 1. Provide internal panels where required for mounting of terminal strips or other equipment.
 2. With plated steel shoulder studs.
 3. Steel with white polyester powder finish.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. General:
 1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050.
 2. Provide outlet box materials to match the conduit system:
 - a. GRC - Cast ferrous boxes.
 - b. RAC - Aluminum (copper free) boxes.
 - c. PCS - PVC coated cast ferrous boxes.
 - d. PVC - PVC boxes.
 3. Solid type gang boxes:
 - a. For more than 2 devices.
 - b. For barriered outlets.
 4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use stainless steel or nylon materials for spacers.
 5. Use cast malleable iron boxes when box must support other devices.
 6. In finished areas:

- a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
- 7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
- 8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
 - a. Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120 V discrete or power wiring.
- 9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
- 10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- C. Outlet boxes:
 - 1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
 - 2. Use deep threaded-hub malleable iron or aluminum boxes:
 - a. In hazardous areas.
 - b. Where exposed to the weather.
 - c. In unheated areas.
 - d. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
 - e. To act as a pull box for conductors in a conduit system.
 - f. Accommodate wiring devices.
 - 3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
 - 4. Outlet boxes may be used as junction boxes wherever possible.
- D. Pull boxes and junction boxes:
 - 1. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
 - 2. Install pull boxes such that access to them is not restricted.
- E. For boxes not indicated:
 - 1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050.
 - 2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
 - a. One-piece, galvanized, pressed steel.
 - 3. Ceiling boxes for flush mounting in concrete:
 - a. Deep, galvanized, pressed steel.
 - 4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
 - a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
 - 5. Outlet, control station, and junction boxes for installation in corrosive locations:
 - a. Fiberglass reinforced polyester, stainless steel, or plastic-coated steel to match the conduit system.
 - b. Furnished with mounting lugs.

6. Boxes for concealed conduit system:
 - a. Non-fire rated construction:
 - 1) Depth: To suit job conditions and comply with the NEC.
 - 2) For luminaries: Use outlet boxes designed for the purpose:
 - a) 50 pounds or less: Box marked "For Fixture Support."
 - b) More than 50 pounds: Box listed and marked with the weight of the fixture to be supported (or support luminaire independent of the box.)
 - 3) For junction and pull boxes: Use galvanized steel boxes with flush covers.
 - 4) For switches, receptacles, etc.:
 - a) Plaster or cast-in-place concrete walls: Use 4-inch or 4-11/16-inch galvanized steel boxes with device covers.
 - b) Walls other than plaster or cast-in-place concrete: Use type of galvanized steel box which will allow wall plate to cover the opening made for the installation of the box.
7. Recessed boxes in fire rated (2 hours maximum) bearing and nonbearing wood or steel stud walls (gypsum wallboard facings):
 - a. Use listed single and double gang metallic outlet and switch boxes.
 - 1) The surface area of individual outlet or switch boxes shall not exceed 16 square inches.
 - b. The aggregate surface area of the boxes shall not exceed 100 square inches per 100 square feet of wall surface.
 - c. Securely fasten boxes to the studs.
 - 1) Verify that the opening in the wallboard facing is cut so that the clearance between the box and the wallboard does not exceed 1/8 inch.
 - d. Separate boxes located on opposite sides of walls or partitions by a minimum horizontal distance of 24 inches.
 - 1) This minimum separation distance may be reduced when wall opening protective materials are installed according to the requirements of their classification.
 - e. Use wall opening protective material in conjunction with boxes installed on opposite sides of walls or partitions of staggered stud construction in accordance with the classification requirements for the protective material.
8. Other fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

F. Recessed boxes:

1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
2. Secure hangers or boxes to wood with 1-inch long cadmium-plated Type A pan head screws:
 - a. Fully or partially hammer-driven screws are not acceptable.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 CLEANING

- A. As specified in Section 16050.

3.04 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16140

WIRING DEVICES

GENERAL

1.02 SUMMARY

- A. Section includes:
 - 1. Switches.
 - 2. Receptacles.
 - 3. Plates.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.

1.03 REFERENCES

- A. As specified in Section 16050.
- B. Federal Specifications (FS):
 - 1. W-C 596 - Connector, Electrical, Power, General Specification for.
 - 2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- C. National Electrical Manufacturers Association (NEMA):
 - 1. WD1 - General Color Requirements for Wiring Devices.
 - 2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
 - 3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
 - 4. WD6 - Wiring Devices Dimensional Specifications.
- D. Underwriters Laboratories Inc. (UL):
 - 1. 20 - General Use Snap Switches.
 - 2. 498 - Standard for Attachment Plugs and Receptacles.
 - 3. 514D - Cover Plates for Flush-Mounted Wiring Devices.

1.04 DEFINITIONS

- A. As specified in Section 16050.
- B. Specific definitions:
 - 1. P-S: Pass and Seymour.
 - 2. Cooper: Cooper Wiring Devices, a division of Cooper Industries.
 - 3. T&B: Thomas and Betts.

1.05 SYSTEM DESCRIPTION

- A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.06 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.
- C. Shop drawings:
 - 1. Engraving schedule:
 - a. Furnish complete engraving schedule for engraved nameplates.

1.07 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Wiring devices shall be UL listed and labeled.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.09 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.10 WARRANTY

- A. As specified in Section 16050.

1.11 SYSTEM START-UP

- A. As specified in Section 16050.

PRODUCTS

2.01 MANUFACTURERS

- A. Switches:
 - 1. One of the following or equal:
 - a. Hubbell.
 - b. Leviton.
 - c. Cooper.
 - 2. Switches for hazardous areas: One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.

2.02 MANUFACTURED UNITS

- A. Switches:
 - 1. General:
 - a. 120-277 VAC.
 - b. 20 ampere.
 - c. Listed in accordance with UL 20.
 - d. Designed and constructed in accordance with FS W-S-896/2.
 - e. Back and side wired unless otherwise indicated.
 - f. Integral grounding terminal.
 - g. Totally enclosed:
 - 1) Color-coded body with color corresponding to ampere rating.
 - h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
 - i. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 2. General purpose switches:
 - a. Toggle type.
 - 3. Switches for hazardous areas:
 - a. Suitable for use in Class I Division 1 and Class I Division 2 locations.
 - b. Factory sealed.
 - c. Through-feed or dead-end as required.
 - 4. Occupancy sensor switches:
 - a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
 - 1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
 - b. Selectable "automatic-on" mode activated by sensors or "manual-on" mode activated by pushbutton.
 - c. Adjustable 5-30 minute time delay.
 - d. Selectable audible alert as a warning before lights turn off.
 - e. Rated for fluorescent lighting loads of up to 800W.
 - f. True multi-way switching allowing identical controls at any location for multi-way switching applications.

5. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
 - a. General:
 - 1) UL listed for wet locations.
 - 2) Gasketed.
 - 3) Die cast metal:
 - a) Match material to box material.
 - b. Switches:
 - 1) Lever operated:
 - a) Provide toggle switch.
6. Corrosive areas:
 - a. Neoprene.
 - b. Gasketed.
 - c. Weatherproof.

EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Mounting heights:
 1. Process and production areas:
 - a. Switches and receptacles 48 inches from finished floor to top of plate.
 2. Offices and finished areas:
 - a. Switches: 48 inches from finished floor to top of plate.
 - b. Receptacles: 18 inches from finished floor to center of plate.
- C. Switches:
 1. Over 300 Volts:
 - a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 DEMONSTRATION AND TRAINING

- A. As specified in Section 16050.
- B. Demonstrate the following to the Engineer and Owner:
 1. Switching is as indicated on the Drawings.
 2. All circuits conform to the panel schedules.
 3. All ground fault receptacles operate at levels below or equal to OSHA maximum allowable fault levels.

3.04 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16150
LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16123 - 600 Volt or Less Wires and Cables.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. D 3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
 - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Installation instructions.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 WARRANTY

- A. As specified in Section 16050.

1.10 SYSTEM START-UP

- A. As specified in Section 16050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EQUIPMENT

- A. Control connections:
 - 1. Use insulated ring type wire terminators for connections to all screw terminals:
 - a. With chamfered/funneled terminal barrel entry.
 - b. Deep internal serrations.
 - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
 - d. Electroplated-tin copper conductor.
 - e. Manufacturer: One of the following or equal:
 - 1) Thomas and Betts, Stakon.
 - 2. For process equipment connections work from manufacturer's drawings.

- B. Joints, splices, taps, and connections:
 - 1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
 - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
 - 1) Manufacturer: One of the following or equal:
 - a) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps.
 - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturer: One of the following or equal:
 - a) Burndy.
 - b) Thomas and Betts.
 - f. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers, one of the following or equal:
 - (1) 3M ITCSN.
 - (2) Thomas & Betts Shrink-Kon.
 - 2. Instrumentation class cable splices:
 - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
 - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
 - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
 - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
 - e. Manufacturer: One of the following or equal:
 - 1) 3M - Scotchcast 72-N.
- C. Insulating tape:
 - 1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
 - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D 3005 Type I.
 - 2) UL 510.
 - 3) CSA C22.2.

- g. Manufacturer: One of the following or equal:
 - 1) 3M - Scotch Number Super 33+.
- 2. General-purpose color-coding tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.
 - 8) Orange.
 - 9) Violet.
 - e. For use as phase identification, marking, insulating, and harnessing.
 - f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
 - g. Manufacturer: One of the following or equal:
 - 1) 3M - Scotch Number 35.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 16050.
- B. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123.
- C. Zero to 600-volt systems:
 - 1. Make all connections with the proper tool and die as specified by the device manufacturer.
 - 2. Use only tooling and dies manufactured by the device manufacturer.
 - 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
 - 4. Number all power and control wires before termination.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.03 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

SECTION 16611

UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL**1.01 SUMMARY**

- A. This Section specifies an on-line, double conversion single-phase uninterruptible power supply (UPS) system to provide backup power for the Digester Complex 2 (DC2) waste gas burner system at the Durham Wastewater Treatment Facility.
- B. The UPS equipment includes a rack-mountable UPS comprising a rectifier/charger; pulse-width-modulation inverter; batteries; equipment indicators, displays and controls; discrete relay outputs; make-before-break, wrap-around maintenance bypass switch; DIN rail mounted circuit breakers and terminals for load outputs; double-hinged, wall-mounted enclosure; and appurtenances.
- C. The UPS integration services include installation, configuration, commissioning, and training for a completely operational UPS system.

1.02 QUALITY ASSURANCE

- A. Referenced Standards: This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

Reference	Title
IEEE 485	Recommended Practice for Sizing Lead – Acid Batteries for Stationary Applications
NFPA 70	National Electrical Code (NEC)
UL1778	Uninterruptible Power Supply Equipment

- B. Label: UPS equipment shall bear a UL or other label acceptable to the inspection authority having jurisdiction for the specific application and be UL1778 listed.
- C. Manufacturer shall have a minimum of 10 years in the design, manufacture, and testing of solid-state UPS systems.
- D. Prior to shipment, the manufacturer shall fully and completely test the system to assure compliance with these specifications and shall include as a minimum: operational discharge and recharge tests to guarantee rated performance.

1.03 SUBMITTALS

- A. Procedure: Section 01330 - Submittal Procedures .
- B. Catalog cuts showing general features of the UPS and batteries.
- C. Battery discharge/recharge calculations showing a minimum of 30 minutes backup time for the specified downstream loads including: 120VAC/2A waste gas burner control panel; 120VAC/1A valve actuator; 120VAC/120mA flow transmitter.

- D. Dimensions and weights of components including working clearances.
- E. Block diagram depicting functional operation of UPS.
- F. Configuration instructions for dry contact relay outputs.
- G. Installation instructions and drawings.
- H. Cabling and termination requirements.
- I. Maximum input and output current.
- J. Wiring diagrams, internal and external.
- K. User's manual.

1.04 PERFORMANCE REQUIREMENTS

- A. Equipment AC Input Characteristics:
 - 1. Normal source: 120 VAC, single-phase, 3-wire.
 - 2. Operating voltage range: +10 to -15 percent (-20 percent without battery discharge).
 - 3. Frequency range: 40 to 70 Hz.
 - 4. Input current distortion: 5 percent total harmonic distortion maximum at full load.
 - 5. Input power factor: 0.98 lagging at full load.
 - 6. Surge protection: Sustains input surges without damage per IEEE C62.41, Category B.
- B. Equipment AC Output Characteristics:
 - 1. Voltage: 120 VAC, single-phase, 3-wire.
 - 2. Load power factor range: 0.5 lagging to 1.
 - 3. Voltage regulation: ± 3 percent nominal for no load to full load.
 - 4. Frequency regulation: 60 Hz ± 5 percent.
 - 5. Frequency synchronized to power source: Automatic disconnect at ± 0.5 Hz.
 - 6. Output power rating: 1500VA at: 0.7 lagging power factor, minimum to maximum DC battery voltage, 0 to 40 degrees C ambient.
 - 7. Voltage transient response: ± 7 percent maximum upon application or removal of 50 to 100 percent load step; recovery to ± 1 percent of steady state within 100 mS.
 - 8. Overload capability: 150 percent for 10 seconds.

1.05 ENVIRONMENTAL REQUIREMENTS

- A. Ambient temperature ranges from 50 to 95 degrees F.
- B. Elevation above sea level is 0 to 500 feet.
- C. Relative humidity 5 to 95 percent, non-condensing.

1.06 SEISMIC ANCHORAGE AND STRUCTURAL DATA:

- A. Mechanical, instrumentation and control, electrical, nonstructural systems, components, and elements permanently attached to the structure shall be anchored and braced to resist seismic forces. Contractor shall design the structural components, seismic attachment, braces, and anchors to the structure.

1.07 EXTENDED WARRANTY

- A. In addition to the manufacturer's standard warranty, the Contractor shall repair or replace without charge to the District, any equipment or part thereof, that the Contractor supplies that fails in operation during normal use within two years from the date of acceptance of the UPS system.

PART 2 PRODUCTS

2.01 CANDIDATE MANUFACTURERS/PRODUCTS

- A. The UPS system shall be capable of providing 1500VA. Acceptable manufacturer includes the following:
 - 1. Eaton 9PX 1500VA UPS with Industrial Relay Card and Maintenance Bypass Power Distribution Unit (PDU).
 - 2. Or approved equal.

2.02 GENERAL

- A. All materials and components shall be new and currently manufactured.
- B. UPS shall be a true on-line system designed to operate in the following modes:
 - 1. Normal: Load is powered by the UPS inverter, which obtains power from upstream normal power.
 - 2. Back-up: Load is powered by the UPS inverter, which obtains power from the battery automatically without interruption, and returns to upstream normal power without interruption.
 - 3. Recharge: Upon restoration of upstream normal power, the input converter shall automatically restart and resume supplying power. The battery charger shall then recharge the batteries.
 - 4. Automatic Restart: Upon restoration of upstream normal power after a power failure that resulted in complete battery discharge, the UPS shall automatically restart and resume supplying power to the load and the battery charger shall automatically recharge the batteries, unless disabled or delayed by the user.
 - 5. Automatic Bypass: UPS failure shall automatically cause the load to transfer from the inverter to the bypass.
 - 6. Manual Bypass: Shall cause an immediate transfer of load from the inverter to the bypass source without disruption to input converter, inverter, and battery charger functions.

2.03 CONVERTER/INVERTER

- A. Converter: Input converter changes incoming ac power to a regulated dc output to the inverter and provides input power factor and input current distortion correction. The input converter shall be provided with:
 - 1. Undervoltage protection (including low-energy surges introduced on the primary source and bypass source)
 - 2. Overvoltage protection.
 - 3. Capability to sustain input surges without damage per IEEE C62.41, Categories A and B.
- B. Inverter: Output inverter converts dc power from the input converter or batteries into precise regulated ac power sine waves. The inverter shall be:
 - 1. Capable of supplying current and voltage for overloads up to 150 percent of full load current for up to 10 seconds.
 - 2. For currents greater than 150 percent or longer time durations, the inverter electronic current-limiting protection shall protect the inverter regardless of the magnitude of connected output overload.
 - 3. Capable of providing control logic to sense overload and disconnect from critical load without needing to clear protective fuses, and to shutdown voltage set point to prevent battery damage from discharging.
 - 4. Automatically transfer to bypass when any of the above conditions are exceeded.

2.04 BATTERY

- A. Provide the required number of battery modules to meet a reserve time of 30 minutes at loads specified.
- B. Batteries shall be sealed maintenance-free, lead acid type with a three- to five-year life expectancy.
- C. Fully charged batteries shall have a specific gravity of 1.215 at 25 degrees C.

2.05 UPS MONITORING AND CONTROLS

- A. UPS Local Display and Alarms: Front panel LEDs and LCD display shall indicate and alarm the following:
 - 1. Indicate only:
 - a. AC Input Failure
 - b. On Battery Power
 - c. Load On/Off
 - d. On Inverter

2. Indicate and audibly alarm:
 - a. Replace Battery Module
 - b. Replace Power Module
 - c. Replace Control Module
 - d. On Bypass
 - e. Low Battery
 - f. Over Temp Warning
 - g. UPS Shutdown
 - h. Output Undervoltage
 - i. Output Overvoltage
 - j. DC bus Overvoltage
 3. Upon fault condition, the UPS shall attempt to maintain load or transfer load to bypass.
 4. UPS shall be provided with an audible alarm silence button.
- B. The UPS shall be provided with 125 VAC/5A, form C, relay contacts for the following:
1. AC Input Failure
 2. On Battery
 3. Low Battery
 4. On Bypass
 5. UPS Fault
- C. UPS Control:
1. Initiate automatic battery test either on a user defined periodic schedule or user defined date and time.
 2. Automatic UPS bypass circuit shall transfer the load to the bypass source based on:
 - a. Inverter overload capacity exceeded
 - b. Inverter over temp
 - c. UPS fault condition
 3. Automatic UPS bypass circuit shall transfer the load, without exceeding transient limits, when an overload or malfunction occurs within the UPS. The bypass shall have an overload rating of 200 percent rated full load for 10 cycles. Automatic bypass shall be inhibited if one of the following conditions exist:
 - a. Inverter/bypass voltage difference exceeds preset limits (± 15 percent of nominal)
 - b. Bypass frequency is out of preset limits (± 5 percent of nominal frequency)
 4. Automatic retransfer of the load back to the UPS shall occur unless:
 - a. It is inhibited by manual control
 - b. Bypass is out-of-synchronization range with inverter output
 - c. Overload condition exists in excess of the inverter full load rating
 - d. There is a UPS fault condition present
 5. Manual internal UPS bypass circuit shall allow power to bypass the rectifier, battery charger, inverter, and battery.

2.06 MAINTENANCE BYPASS SWITCH POWER DISTRIBUTION UNIT

- A. Mounted in common enclosure with UPS.
- B. Provides complete “wrap-around” protection to allow the UPS to be pulled from service. The “wrap-around” allows the electrical load to be connected to the upstream normal power during UPS and battery maintenance. Provide a make-before-break bypass for the UPS and battery without shutting down the load.
- C. Acceptable product is Eaton HotSwap MBP Catalog No. EHBPL1500R-PDU1U or approved equal.

2.07 DIN RAIL, OUTPUT CIRCUIT BREAKER AND TERMINALS ASSEMBLY

- A. Provide a rack-mounted 35 mm DIN rail assembly complete with output circuit breakers, terminals and internal wiring as shown in the drawings.

2.08 RACK ENCLOSURE

- A. UPS, maintenance bypass switch PDU, and DIN rail assembly shall be housed in a wall-mounted, double hinged, NEMA 1, 24 bay (24U) rack enclosure.
- B. Acceptable product is Eaton VLWM2425PB or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Equipment Mounting:
 - 1. Install uninterruptible power supply, maintenance bypass PDU and DIN rail for output load interconnection in the double-hinged, wall-mounted 24U rack enclosure as shown in the drawings. Installation per the manufacturer’s installation instruction.
 - 2. Wall mount the UPS panel at the approximate location shown on the drawings. Coordinate final location with the Owner. Provide seismic anchorage and bracing.

3.02 FIELD TESTING

- A. In addition to any testing herein, perform all testing for this product or system consistent with the requirements of applicable codes, and the manufacturer’s current quality assurance program.
- B. Test prior to operational use.
- C. Load Test:
 - 1. Use 0.8 power factor load bank.
 - 2. Disconnect ac input and operate UPS at rated load.
 - 3. Record operating time and battery voltage.
 - 4. Continue operation at rated load battery cutoff.
 - 5. Monitor battery voltage and record value just prior to cutoff.

- D. Battery Recharge Test: Connect ac power to each battery module in low batter state and record battery specific gravity. Allow battery module to be charged and record battery specific gravity at end of specified recharge duration.
- E. Relay Output Test: Verify relay outputs are correctly configured. Verify that “UPS Fail” contacts are wired to and correctly monitored by 120VAC digital input at PLC panel. Verify that “AC Input Fail” contacts are wired to and correctly monitored by “Full Open Override” input at actuator for flow valve.

END OF SECTION

DIVISION 17	Instrumentation
17101	Control Loop Description

D60_135_CTL_040_DigesterComplex2WasteGasBurner.htm

Control Loop Description	Digester Complex 2 Waste Gas Burner														
Process Description:															
<p>The waste gas burner (WGB) burns digester gas in excess of the quantity consumed by cogen and boilers. Digester gas pressure is monitored at the digesters and digester gas is transmitted to the WGB where the header is split into two parallel lines. For low demand events, the mechanical pressure relief valve in the primary line opens at its primary pressure setpoint sending digester gas to the WGB. For high demand events, digester gas pressure may continue to rise despite the mechanical relief valve having adjusted to a fully open position. For these high demand events, the flow valve in the secondary (bypass) line fully opens at its secondary pressure setpoint to allow for additional flow to the WGB. A flow meter is provided to quantify the total amount of digester gas sent to the burner.</p> <p>Digester gas control panel 20LCP30201, digester gas flow transmitter 20FIT30201 and digester gas flow valve 725FV6901 are fed from a UPS source to enable their operation during utility outages.</p>															
Last Update: April 29, 2019	Approved By: DRAFT														
Equipment															
Unit Equipment:															
<table> <tr> <th>Equipment Name</th><th>Tag Number</th></tr> <tr> <td>Waste Gas Burner</td><td>20M30201</td></tr> <tr> <td>Waste Gas Burner Local Control Panel</td><td>20LCP30201</td></tr> <tr> <td>Waste Gas Buner Spark Generator Panel</td><td>20LCP30202</td></tr> </table>		Equipment Name	Tag Number	Waste Gas Burner	20M30201	Waste Gas Burner Local Control Panel	20LCP30201	Waste Gas Buner Spark Generator Panel	20LCP30202						
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Waste Gas Buner Spark Generator Panel	20LCP30202														
Instrumentation:															
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Control Strategies															
Local Control Operation and Alarm Reset															
VFD Control Panel															

<ul style="list-style-type: none"> • None
Motor Control Center
<ul style="list-style-type: none"> • None
MFR Control Center
<ul style="list-style-type: none"> • Self-contained unit that comes equipped with the manufacturer furnished local control panel. • In AUTO mode, the burner only uses digester gas when signaled from the PLC that digester gas will be available as fuel; otherwise it is off (no pilot). • With the POWER OFF/ON selector switch in the POWER ON position, 120 volts AC is provided to the pilot controller. <ul style="list-style-type: none"> ○ With the pilot controller's STANDBY/AUTO/MANUAL selector switch in STANDBY, the controller will not attempt to light pilot regardless of digester gas system pressure. ○ AUTO is the normal operating position. <ul style="list-style-type: none"> ▪ With the switch in AUTO, pilot ignition cycle starts when digester system pressure increases to 10.5 inches water column. ▪ The Waste Gas Burner will flare digester gas when the pressure in the digesters reaches the primary setpoint (12.0 inches of water column, operator adjustable). The relief valve opens and digester gas flows through the primary line to the Waste Gas Burner. ○ MANUAL position permits the operator to manually light the pilot. <ul style="list-style-type: none"> ▪ By pushing the MANUAL IGNITER switch at the Local Control Station, the operator will start a spark igniter.
Local Control Station
<ul style="list-style-type: none"> • The waste gas burner can be operated locally only. No control is possible from SCADA. • The Thermocouple Control 1 ENABLE/DISABLE enables the thermocouple to sense pilot ON/OFF status. A red LED ON at the Local Control Station signifies that the unit is ENABLED. • A remote start simulator switch (RSSS) at the Local Control Station has two positions: <ul style="list-style-type: none"> ○ In ON, a high pressure condition is simulated in the digester gas system, which starts the pilot controller's pilot lighting sequence. ○ In OFF, the pilot ignition is controlled by the digester gas system. The pilot controller will start the pilot lighting sequence if activated by the digester gas high pressure switch.
Intermediate Control Panel
<ul style="list-style-type: none"> • None
SCADA Control Operation and Alarm Reset
SCADA Manual

<ul style="list-style-type: none"> • None
SCADA Auto
<ul style="list-style-type: none"> • The control loop serves to relieve over-pressurization in the digesters by opening the flow valve 725FV6901 in the bypass line. In normal conditions, the flow valve is fully closed (4 mA position command from SCADA). • Digesters 1 and 2 gas pressure is sensed by pressure transmitters 20PIT10401 and 20PIT10402 respectively. If the pressure in either digester reaches or exceeds the bypass setpoint (14.0 inches of water column, operator adjustable), flow valve 725FV6901 is fully opened (20 mA position command from SCADA). The flow valve will remain open until the pressure in both digesters drops below a deadband from the setpoint (2.0 inches of water column, operator adjustable; so flow valve closes at 12.0 inches of water column).
SCADA Display
Status and Process Display
<ul style="list-style-type: none"> • Waste Gas Burner ON. • Waste Gas Burner FAULT. • Digester 1 Gas Pressure Indicating Transmitter. • Digester 2 Gas Pressure Indicating Transmitter. • Digester Gas Flow to Waste Gas Burner. • Flow Valve Position Command. • Flow Valve Position Feedback.
Operator Entries
<ul style="list-style-type: none"> • Secondary Line Pressure Setpoint (Flow Valve Initial Position)
SCADA Alarms and Resets
<ul style="list-style-type: none"> • NATURAL GAS PADDING IN USE. • DIGESTER GAS TO BURNER FLOW TRANSMITTER Fault (out of range). • Digester 1 Gas Pressure Fault (out of range) • Digester 2 Gas Pressure Fault (out of range) • Flow Valve Fail (position feedback out of tolerance by 5%). • WASTE GAS BURNER FAULT. • UPS FAULT
Hard-Wired Interlocks
<ul style="list-style-type: none"> • On loss of utility power, the PLC will no longer be energized and the 4-20 mA position command signal to the flow valve will no longer be provided. The flow valve actuator is configured to adjust to a “fail-safe” open position of 100% on loss of position command signal to prevent over-pressurization due to shutdown of digester gas consuming equipment on loss of utility power.

- On loss of utility power, the UPS will be supplying loads from battery power. “On Battery Power” relay output from UPS is hardwired to a dry contact override input at the flow valve to drive the flow valve to a fully open position.
- The pilot is to be ON whenever the bypass valve is not fully closed. Accordingly, fully closed relay output from flow valve is hardwired in parallel with digester gas pressure switch 20PSH30201 to the remote start contacts at waste gas burner local control panel 20LCP30201.

Software Interlocks

- Interlock signal for alarm when digester gas pressure falls below 3 inches water column causing pressure relief valves 20PRV30201 and 20PRV30202 to open for natural gas padding of Digesters 1 and 2.
- Interlock signal for alarm when digester gas pressure falls below a predetermined setpoint (initially set at 7 inches water column) causing boiler valves to switch to natural gas fuel.

Historical Trending

- Daily Gas Usage by Waste Gas Burner.
- Digester Gas Flow to Waste Gas Burner.
- Digester Pressure 1.
- Digester Pressure 2.
- Flow Valve Position.

Equipment Failure Sequence

- None

Equipment Automatic Failover Sequence

- None

END OF DOCUMENT

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