

CLAYTON COUNTY WATER AUTHORITY
MORROW, GA



PROJECT MANUAL

FOR

BID NUMBER: 2022-WP-15

W.J. HOOPER WPP AND TERRY R. HICKS WPP
UV SYSTEM UPGRADES

SEPTEMBER 2022

CONFORMED DOCUMENTS

VOLUME 2 OF 3
TECHNICAL SPECIFICATIONS
DIVISIONS 02-46

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JACOBS Project No.
EEXJ6935
SEPTEMBER 2022

SECTION 00 01 01
PROJECT TITLE PAGE

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Project No. EEXJ6935

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TECHNICAL SPECIFICATIONS

**SECTION 02 41 00
DEMOLITION**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI): A10.6, Safety Requirements for Demolition Operations.
 2. Occupational Safety and Health Administration (OSHA), U.S. Code of Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety and Health Regulations for Construction.
 3. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
 - a. Part 61—National Emission Standards for Hazardous Air Pollutants.
 - b. Part 82—Protection of Stratospheric Ozone.
 - c. Part 273—Standards for Universal Waste Management.
 4. Crane Manufacturers Association of America (CMAA):
 - a. CMAA 70 – Multiple Girder Cranes.
 - b. CMAA 74 – Single Girder Cranes.
 - c. CMAA 78 – Professional Services.

1.02 DEFINITIONS

- A. Demolition: Dismantling, razing, destroying, or wrecking of any fixed building or structure or any part thereof. Demolition also includes removal of pipes, manholes tanks, conduit, and other underground facilities, whether as a separate activity or in conjunction with construction of new facilities.
- B. Modify: Provide all necessary material and labor to modify an existing item to the condition indicated or specified.
- C. Relocate: Remove, protect, clean and reinstall equipment, including electrical, instrumentation, and all ancillary components required to make the equipment fully functional, to the new location identified on the Drawings.
- D. Renovation: Altering a facility or one or more facility components in any way.
- E. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste; such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

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- F. Universal Waste Lamp: In accordance with 40 CFR 273, the bulb or tube portion of an electric lighting device, examples of which include, but are not limited to, fluorescent, high-intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps.
- G. Universal Waste Thermostat: A temperature control device that contains metallic mercury in an ampule attached to a bimetal sensing element, and mercury-containing ampules that have been removed from these temperature control devices in compliance with the requirements of 40 CFR 273.

1.03 SUBMITTALS

A. Informational Submittals:

1. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started. Submit Demolition/Relocation Plan a minimum of 30 days prior to when related activities are to commence.
2. Schedule a Demolition Plan meeting with the Owner to review the Plan and schedule for demolition activities relative to the phases of construction and continuity of operations.
3. Submit copies of any notifications, authorizations and permits required to perform the Work.
4. Copies of reports and other documentation required for abandoning wells.

B. Submit a shipping receipt or bill of lading for all universal waste shipped.

C. Submit copies of Crane Inspector certifications and qualifications.

D. Submit proposed checklist for crane inspections for pre- and post-construction inspections a minimum of 30 days prior to when related activities are to commence.

E. Submit completed checklist for crane inspections for pre- and post-construction inspections on inspections are completed.

1.04 QUALITY ASSURANCE

A. Qualifications: Crane Inspectors shall be certified in accordance with the requirements of CMAA Specification 78 or equivalent. Crane Inspectors shall have a minimum of 2,000 hours relevant experience and/or formal training in maintenance, servicing and repairing, and testing and modifying cranes and hoists.

1.05 REGULATORY AND SAFETY REQUIREMENTS

- A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.
- B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor's safety requirements shall conform to ANSI A10.6.
- C. Furnish timely notification of this demolition project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.06 DEMOLITION/RENOVATION PLAN

- A. Demolition/Renovation Plan shall provide for safe conduct of the Work and shall include:
 - 1. Detailed description of methods and equipment to be used for each operation.
 - 2. The Contractor's planned sequence of operations, including coordination with other work in progress.
 - 3. Procedures for removal and disposition of materials specified to be salvaged.
 - 4. Disconnection schedule of utility services.
- B. Include statements affirming Contractor inspection of the existing roof deck, floors, walls, and framing members, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work.

1.07 SEQUENCING AND SCHEDULING

- A. Demolition shall not commence at each site until within 30 days of scheduled delivery of process piping.
- B. The Work of this Specification shall not commence until Contractor's Demolition/Renovation Plan has been approved by Engineer.
- C. The use of the existing bridge cranes in the facilities shall not commence until Contractor's selected Crane Inspector has been approved to meet Qualifications and Contractor's Pre-Construction Inspection Plan and Checklist have been completed and approved by Engineer.
- D. Include the Work of this Specification in the progress schedule, as specified in Section 01 32 00, Construction Progress Documentation.

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1.08 ENVIRONMENTAL PROTECTION

- A. Ensure any chemicals in the existing chemical tanks at both Hooper WPP and Hicks WPP are disposed off from the facility in a safe manner. In case of any chemical spills, follow instructions provided in the safety data sheets for those chemicals.
- B. Ensure that the UV system is also disposed off the Site in a safe manner from both Hooper WPP and Hicks WPP.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

- A. Facilities:
- B. Portions of buildings and other areas scheduled for selective demolition, partial demolition, and renovation Work are as shown in the Drawings for Hicks WPP and Hooper WPP.
- C. Utilities and Related Equipment:
 - 1. Notify Owner or appropriate utilities to turn off affected services at least 48 hours before starting demolition or renovation activities.
 - 2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
 - 3. When utility lines are encountered that are not indicated on the Drawings, notify Engineer to further work in that area.
 - 4. Remove meters and related equipment and deliver to a location as determined by the Engineer.
- D. Concrete:
 - 1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished Work, and the remaining concrete is sound.

2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on the Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16 inch. Rebar and small embeds at existing concrete may be required to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on the Drawings.

E. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include:

F. Fill holes and depressions caused by previous physical damage or left as a result of removals in existing masonry or concrete walls with an approved patching material, applied in accordance with the manufacturer's printed instructions.

G. Cylinders and Canisters: Remove all fire suppression system cylinders and canisters and dispose as specified in Paragraph Ozone Depleting Substances (ODS).

H. Electrical:

1. Cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4 inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on the Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.
4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.

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5. Raceways and cabling not scheduled for reuse.
 6. Inaccessibly Concealed: Cut off and abandon in place.
 7. Exposed or Concealed Above Accessible Ceilings: Remove.
 8. Raceways and Cabling Scheduled for Future Use: Cap/seal and tag.
 9. Relocating Equipment: Extend existing wiring or run new wiring from the source.
 10. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
 11. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
 12. Provide new typewritten panelboard circuit directory cards.
- I. Universal Waste Lamps and Thermostats: Manage, contain, package, and label in strict accordance with 40 CFR 273.

3.02 USE OF EXISTING BRIDGE CRANES

A. Pre-Construction Inspection:

1. Contractor shall select and furnish certified Crane Inspector to perform pre-construction inspection of existing bridge crane prior to crane's use during any demolition activities.
2. Any existing deficiencies or damages to the existing crane, crane accessories, supporting structural members, or other related items shall be identified and repaired or replaced as directed by Engineer prior to use of the crane.
3. Costs associated with repairs or replacements related to existing deficiencies or damages shall be documented and itemized by Contractor and furnished by Owner.

B. Post-Construction Inspection:

1. Contractor shall select and furnish certified Crane Inspector to perform post-construction inspection of existing bridge crane once the Work requiring use of the existing bridge crane has been completed and prior to Contractor demobilization from site.
2. Any Contractor-damaged items or deficiencies to the existing crane, crane accessories, supporting structural members, or other related items that resulted from construction activities shall be identified and repaired or replaced as directed by Engineer prior to Contractor demobilization from site.
3. Costs associated with repairs or replacements related to Contractor-damaged items shall be documented and furnished by Contractor.

- C. Do not use existing bridge crane for loads greater than load limits and load ratings printed on crane.

3.03 PROTECTION

- A. Building Occupancy: Refer to Section 01 31 13, Project Coordination, for specific requirements related to concurrent occupancy of facilities to be partially demolished.
- B. Dust and Debris Control:
 - 1. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
 - 2. Clean the Work area daily.
 - 3. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to vehicular traffic.
- C. Existing Work:
 - 1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
 - 2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
 - 3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
 - 4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.
 - 5. Do not overload pavements to remain.
- D. Facilities:
 - 1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.

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2. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
3. Protect all facility elements not scheduled for demolition.
4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.

E. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
2. Provide temporary barricades and other forms of protection to protect Owner's personnel and the general public from injury due to demolition Work.
3. Provide protective measures as required to provide free and safe passage of Owner's personnel and the general public to occupied portions of the structure.

3.04 BURNING

- A. The use of burning at the Site for the disposal of refuse and debris will not be permitted.

3.05 RELOCATIONS

- A. Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Clean all items to be relocated prior to reinstallation, to the satisfaction of Engineer. Repair items to be relocated which are damaged or replace damaged items with new undamaged items as approved by Engineer.

3.06 TITLE TO MATERIALS

- A. All salvaged equipment and materials will remain the property of Owner.
- B. With the exception of the following listed salvaged equipment and materials, all items designated to be removed shall become the property of Contractor:
1. Ductile iron pipe fittings.
 2. Ductile iron valve and operators.

- C. Title to equipment and materials resulting from demolition is vested in the Contractor upon approval by Engineer of Contractor's Demolition/Renovation Plan, and the resulting authorization by Engineer to begin demolition.

3.07 DISPOSITION OF MATERIAL

- A. Do not remove equipment and materials without approval of Contractor's Demolition/Renovation Plan by Engineer.
- B. Salvage equipment and material to the maximum extent possible.
- C. Remove materials and equipment that are indicated to be removed by Contractor and deliver to a storage site as directed on the Site.
- D. Remove salvaged items in a manner to prevent damage, and pack or crate to protect the items from damage while in storage or during shipment. Properly identify containers as to contents.
- E. Repair or replace, at the discretion of Engineer, items damaged during removal or storage.
- F. Remove salvaged items designated as the property of Owner in a manner to prevent damage. Properly identify containers as to contents.
- G. Repair or replace, at the discretion of Engineer, items damaged during removal or storage.
- H. Deliver salvaged items that are designated as the property of Owner to a storage site as directed on the Site.
- I. Owner will not be responsible for the condition or loss of, or damage to, property scheduled to become Contractor's property after Engineer's authorization to begin renovation. Materials and equipment shall not be viewed by prospective purchasers or sold on the Site.
- J. Owner will not be responsible for the condition or loss of, or damage to, such property after Engineer's authorization to begin demolition.
- K. Store salvaged items as approved by Engineer and remove them from Owner's property before completion of the Contract. Materials and equipment shall not be either viewed by prospective purchasers or sold on the Site.

3.08 REUSE OF MATERIALS AND EQUIPMENT

- A. Remove and store materials and equipment listed in Article Title To Materials to be reused or relocated to prevent damage, and reinstall as the Work progresses.

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- B. Properly store and maintain equipment and materials in same condition as when removed.
- C. Store equipment and material designated to be reused in a location designated by Engineer.
- D. Equipment and material designated to be reused shall be cleaned, serviced and checked for proper operability before being put back into service.
- E. Engineer will determine condition of equipment and materials prior to removal.

3.09 DISASSEMBLY AND REASSEMBLY OF MATERIALS

- A. Prior to disassembly of materials, identify any damaged materials requiring replacement, and provide calculations for all materials. Include cost breakdown for Engineer's review.
- B. Catalogue and store materials intended for disassembly and reassembly as indicated on the Drawings.
- C. Replace all damaged and non-catalogued materials and provide calculations for all materials intended for reassembly as indicated on the Drawings.
- D. Items identified to be removed during construction that are damaged prior to reassembly by Contractor shall be replaced at no cost to Owner.
- E. See Drawings for site-specific disassembly and reassembly requirements.
- F. Prior to reassembly, Engineer and Contractor shall inspect materials to determine condition. Engineer may direct Contractor to replace materials deemed unsuitable for reassembly.

3.10 SPECIALIZED SALVAGE

- A. Historical Items:
 - 1. Remove in a manner to prevent damage.
 - 2. The following historical items shall be delivered to Owner for disposition:
 - a. Ductile iron pipe fittings.
 - b. Ductile iron valve and operators.

3.11 UNSALVAGEABLE MATERIAL

- A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of offsite.
- B. Combustible material shall be disposed of the Site.
- C. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.12 CLEANUP

- A. Debris and rubbish shall be removed from basement and similar excavations. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

SECTION 03 31 03
MISCELLANEOUS STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 SCOPE

- A. Furnish and install concrete as shown on the Drawings and as specified herein. Design and detail components, where specified herein.
- B. Furnish labor, material, equipment and incidental items necessary to complete Work.
- C. ACI 301-20 shall be the base specifications in conjunction with additions and modifications as noted herein. ACI 301 requirements related to the Work shall apply whether or not they are referenced herein. In case of conflict, the more stringent requirement shall apply.

1.02 REFERENCES

- A. Where referenced by the governing code, the adopted edition shall apply. Otherwise, the latest edition of the reference shall apply, unless otherwise noted.
- B. The following is a list of standards which may be referenced in this section:
 - 1. American Concrete Institute (ACI): 301, Specifications for Concrete Construction.
 - 2. ASTM International (ASTM):
 - a. ASTM A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - b. ASTM A1064/A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - 3. NSF International (NSF): NSF 61, Drinking Water System Components – Health Effects.

1.03 DEFINITIONS

- A. Authority Having Jurisdiction (AHJ): Permitting agency including, but not limited to, federal, state, local, or other regional department; or environmental department; or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department; electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.

1.04 ABBREVIATIONS

- A. PSI: Pounds per square inch.

1.05 SUBMITTALS

- A. Submit documents in accordance with Division 01, General Requirements.
- B. Prior to other submittal requirements herein, submit a copy of ACI 301-20 for documentation of complete specifications for cast-in-place concrete.
 - 1. A hard copy of the document shall be kept with the project specifications at the Project site at all times.
- C. Action Submittals: All submittal requirements identified in ACI 301, unless otherwise determined by Engineer.
- D. Informational Submittals:
 - 1. Any Action Submittals deemed by Engineer to be Informational Submittals at time of submittal.
 - 2. Submit certificate(s) of compliance with NSF 61 for each applicable product.

1.06 SITE CONDITIONS

- A. Prior to installation, visit and examine the Work site and take into consideration conditions that may affect the Work including, but not limited to:
 - 1. Existing conditions of adjoining properties, river embankment, underground utilities and/or structures, streets, buildings and plant operations.
 - 2. Conditions of public thoroughfares and roads for availability, clearances, loads, restrictions, and other limitations affecting transportation to and ingress/egress from the project site.
- B. Conform to state and local regulations.

1.07 DELIVERY, STORAGE AND HANDLING

- A. To the extent it is practical, factory assemble items provided hereunder.
- B. In preparation for shipment, package and clearly tag parts and assemblies that are shipped unassembled of necessity in a manner that will protect materials from damage and that will facilitate identification and final assembly in field.

- C. Store and handle products in accordance with manufacturer’s recommendations and in such a manner as to prevent damage of any kind, including overexposure to sunlight.

PART 2 PRODUCTS

2.01 FORMWORK AND FORMWORK ACCESSORIES

- A. Comply with ACI 301 Section 2.2 except as modified herein.
- B. Form ties in buried, exterior, wet or humid environments shall have a setback or break-back distance of 1.5 inches.

2.02 REINFORCEMENT AND REINFORCEMENT SUPPORTS

- A. Comply with ACI 301 Section 3.2 except as modified herein.
- B. Steel reinforcing bars shall meet ASTM A615/A615M Grade 60.
- C. Welded wire reinforcement shall be fabricated, shipped, stored and installed in flat sheets. Do not use rolls.
- D. Reinforcement supports in buried, exterior, wet or humid environments shall be precast concrete or plastic.

2.03 CONCRETE MIXTURES

- A. Comply with ACI 301 Section 4.2 except as modified herein.
- B. For each type of concrete element listed below, concrete mix design(s) shall meet the 28-day design compressive strength and the requirements in ACI 301 based on the exposure categories:

Concrete Elements	Minimum 28-Day Design Compressive Strength	Exposure Categories
All concrete elements, unless otherwise noted	4,000 psi	F0, S0, W1, C1

2.04 REPAIR MATERIAL

- A. Comply with ACI 301 Section 5.2.

2.05 BONDING AGENT

- A. Comply with ACI 301 Section 5.2.

2.06 HANDLING, PLACING AND CONSTRUCTING

- A. Comply with ACI 301 Section 5.2.

PART 3 EXECUTION

3.01 FORMWORK AND FORMWORK ACCESSORIES

- A. Comply with ACI 301 Section 2.3.

3.02 REINFORCEMENT AND REINFORCEMENT SUPPORTS

- A. Comply with ACI 301 Section 3.3.

3.03 CONCRETE MIXTURES

- A. Comply with ACI 301 Section 4.3.

3.04 REPAIR MATERIAL

- A. Comply with ACI 301 Section 5.3.

3.05 BONDING AGENT

- A. Comply with ACI 301 Section 5.3.

3.06 HANDLING, PLACING AND CONSTRUCTING

- A. Comply with ACI 301 Section 5.3 except as modified herein.
- B. Finished Formed Surfaces: Finish formed surfaces in accordance with ACI Section 5.3.3.1, except as modified herein:
 - 1. Surfaces exposed to view, unless otherwise specified: Rubbed finish.
 - 2. Edges of equipment pads with exposed sides less than 12 inches: Surface finish SF-1.

3.07 FIELD QUALITY ASSURANCE AND QUALIT CONTROL

- A. General: Comply with ACI 301 Section 1.7 in addition to the requirements herein.

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- B. Owner-Furnished Quality Assurance will be provided in accordance with the Statement of Special Inspections. Refer to Section 01 45 33, Special Inspection, Observation, and Testing.
- C. Contractor-Furnished Quality Control: Comply with:
 - 1. Section 01 45 16.13, Contractor Quality Control.
 - 2. ACI 301 Section 2.3.5.

END OF SECTION

SECTION 03 62 00
GROUTING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
 - b. C307, Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacing.
 - c. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - d. C579, Standard Test Methods for Compressive Grout Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - e. C882, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
 - f. C939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
 - g. C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
 - h. C1107/C1107M, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
 - i. C1181, Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
 - j. D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

1.02 SUBMITTALS

- A. Action Submittals:
1. Product data of grouts.
 2. Proposed method for keeping existing concrete surfaces wet prior to placing nonshrink grout.
 3. Forming method for fluid grout placements.
 4. Curing method for grout.

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B. Informational Submittals:

1. Manufacturer's Written Instructions:
 - a. Adding fiber reinforcing to batching.
 - b. Mixing of grout.
2. Manufacturer's proposed training schedule for grout work.
3. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements.
 - a. Grout free from chlorides and other corrosion-causing chemicals.
 - b. Nonshrink grout properties of Category II, verifying expansion at 3 days or 14 days will not exceed the 28-day expansion and nonshrink properties are not based on gas or gypsum expansion.
4. Manufacturer's Certificate of Proper Installation.
5. Statements of Qualification: Grout manufacturer's representative.
6. Test Reports:
 - a. Test report for 24-hour evaluation of nonshrink grout.
 - b. Test results and service report from demonstration and training session.
 - c. Field test reports and laboratory test results for field-drawn Samples.
7. List of Contractor's equipment installation staff trained by grout manufacturer's representative in: Nonshrink grout installation and curing.

1.03 QUALIFICATIONS

- A. Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of 1-year experience that has resulted in successful installation of grouts similar to those for this Project.
- B. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Nonshrink Grout Test Form, attached at the end of this section. Provide independent testing laboratory test results for testing conducted within last 18 months.

PART 2 PRODUCTS

2.01 NONSHRINK GROUT AND EPOXY GROUT SCHEDULE

- A. Furnish nonshrink grout (Category I, II, and III) and epoxy grout for applications as indicated in the following schedule:

Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
All locations on the project unless otherwise specified.	II		II

2.02 NONSHRINK GROUT

- A. Category II:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
 - a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
 - b. Temperatures of 40 degrees F, 80 degrees F, and 90 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturers and Products:
 - a. BASF Building Systems, Inc., Shakopee, MN; MasterFlow 928.
 - b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
 - c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
 - d. Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.
 - e. US MIX Co., Denver, CO; US SPEC MP Grout.
 - f. "Or-Equal."

PART 3 EXECUTION

3.01 GROUT

- A. General: Mix, place, and cure grout in accordance with grout manufacturer's representative's training instructions.

3.02 FIELD QUALITY CONTROL

A. General:

1. Performed by Project representative's inspection staff.
2. Perform the following quality control inspections. The grout manufacturer's representative shall accompany the Project representative's inspection staff on the first installation of each size and type of equipment.

B. Evaluation and Acceptance of Nonshrink Grout:

1. Inspect the surface preparation of concrete substrates onto which nonshrink grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
2. Inspect preparation and application of nonshrink grout form work for conformance to the manufacturer's recommendations.
3. Conduct a final review of completed nonshrink grout installation for conformance to these Specifications.
4. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
5. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/ C1107M.
6. For large grout applications, make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
7. Consistency: As specified in Article Nonshrink Grout. Flow cone test in accordance with ASTM C939. Grout with consistencies outside range requirements shall be rejected.
8. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
9. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.

10. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
11. Perform bleeding test in accordance with ASTM C940 to demonstrate grout will not bleed.
12. Store cubes at 70 degrees F.
13. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.
14. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

3.03 MANUFACTURER'S SERVICES

A. General:

1. Coordinate demonstrations, training sessions, and applicable Site visits with grout manufacturer's representative. Allow 2-week notice to grout manufacturer's representative for scheduling purposes.
2. Provide and conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of grout.
3. Necessary equipment and materials shall be available for demonstration.
4. Conduct training prior to equipment mount installation work on equipment pads.
5. Training for each type of grout shall be not less than 4 hours' duration.

B. Nonshrink Grout Training:

1. Training is required for all Type II grout installations.
2. Provide nonshrink grout installation training by the qualified grout manufacturer's representative for Contractor's workers that will be installing nonshrink grout for baseplates and equipment mounts. Schedule training to allow Engineer's attendance.
3. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and form tie-through bolt holes to provide actual on-the-job training.
4. Use minimum of two bags for each grout Category II. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Include recommended grout curing methods in the training.
6. Transport test cubes to independent test laboratory and obtain test reports.

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7. Training by manufacturer’s representative does not relieve Contractor of overall responsibility for this portion of the Work.
8. Submit a list of attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

3.04 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is part of this Specification.
 1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

SUPPLEMENT 1

(Test Lab Name)

(Address)

(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain three bags of each type of grout.

1. From intended grout supplier for Project.
2. Three bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

- A. Product data and warranty information contained in company literature and data? Yes_____ No_____
- B. Literature and bag information meet specified requirements? Yes_____ No_____
- C. Manufacturer guarantees grout as specified in Article Guarantee? Yes_____ No_____
- D. Guarantee extends beyond grout replacement value and allows participation with Contractor in replacing and repairing defective areas? Yes_____ No_____
- E. Water demands and limits printed on bag? Yes_____ No_____
- F. Mixing information printed on the bag? Yes_____ No_____
- G. Temperature restrictions printed on bag? Yes_____ No_____

*Rejection of a grout will occur if one or more answers are noted NO.

GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____
2. List expiration date. _____
3. Weigh bags and record weight. _____

Owner's Representative will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of three bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10-gallon pail.
2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).
3. Use maximum water allowed per water requirements listed in bag instructions.
4. Mix grout to maximum time listed on bag instructions.
5. In accordance with ASTM C939 (flow cone) determine time of mixed grout through the flow cone. _____ seconds
6. Add water to attain 20- to 30-second flow in accordance with ASTM C939.
7. Record time of grout through cone at new water demand. _____ seconds
8. Record total water needed to attain 20- to 30-second flow. _____ pounds
9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, ASTM C1107/C1107M will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.
2. Place one can of grout in tub of ice water and leave one can at ambient temperature.
3. Cover top of both cans with glass or plastic plate preventing evaporation.
4. Maintain 38 degrees F to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1 hour.
5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and Category III):

1. Divide the remaining grout into two 3-gallon cans. Place the cans into the 40-degree F and 90-degree F containers and leave for 20, 40, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4 inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.
2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take a ASTM C939 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 degrees F and 90 degrees F.
 - a. 20 min _____, sec. @ 40 degrees F.
 - b. 40 min _____, sec. @ 40 degrees F.
 - c. 60 min _____, sec. @ 40 degrees F.
 - d. 20 min _____, sec. @ 90 degrees F.
 - e. 40 min _____, sec. @ 90 degrees F.
 - f. 60 min _____, sec. @ 90 degrees F.

All Category II and Category III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

Qualified

Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with ASTM C1107/C1107M for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.
2. Store cubes at 70 degrees F for 24 hours.
3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are less than 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

Signature of Independent Testing Laboratory

Date Test Conducted

**SECTION 03 63 00
CONCRETE DOWELING**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American National Standards Institute (ANSI).
 2. ASTM International (ASTM):
 - a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
 3. International Code Council (ICC):
 - a. 2018 International Building Code (IBC).
 - b. Evaluation Services Reports.
 4. NSF International (NSF): 61, Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

- A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.
- B. Special Inspection: As defined in the ICC IBC and indicated on the Statement of Special Inspection (Plan) in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing.

1.03 SUBMITTALS

- A. Action Submittals:
1. Product Data: Manufacturer's catalog information.
- B. Informational Submittals:
1. Manufacturer's instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
 2. Manufacturer's written letter of certification identifying installer's qualifications to install products.
 3. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

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1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: At least three similar projects with same products within last 3 years.
 - 2. Installer: Trained and certified by manufacturer.
- B. Regulatory Requirements: Adhesive shall be certified as meeting NSF 61 for use in potable water structures.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
- B. Store adhesive components in accordance with manufacturer's written instructions.
- C. Dispose of when:
 - 1. Shelf life has expired.
 - 2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Adhesive:
 - 1. Approved by an ICC Evaluation Services Report for conformance to 2018 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
 - 2. Suitable for long-term loads as well as for wind and seismic loads.
 - 3. Meet requirements of ASTM C881/C881M.
 - 4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
 - 5. Disposable, Self-Contained Cartridge System:
 - a. Capable of dispensing both components in proper mixing ratio.
 - b. Fit into manually or pneumatically operated caulking gun.
 - 6. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
 - 7. Potable Water Structures: Adhesive shall be acceptable for use by NSF 61.

8. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; HIT-RE 500-V3 (ESR-3814) or HIT-HY 200 (ESR-3187) Adhesive Anchors.
 - b. DeWalt Anchors & Fasteners, Brewster, NY; PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-3G Epoxy Adhesive Anchors (ESR-4057).
 - d. “Or-Equal.”
- B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.
- C. Reinforcing Dowels: As specified in Section 03 31 03, Miscellaneous Structural Concrete.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Drilling Equipment:
 1. Drilling Hammers for Dowel Holes:
 - a. Electric or pneumatic rotary type with medium or light impact.
 - b. Hollow drills with flushing air systems are preferred.
 2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.
- C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.
- D. Doweling:
 1. Install per details shown on the Drawings and in accordance with adhesive manufacturer’s instructions.
 2. When using epoxy anchors, dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
 3. Bent Bar Dowels: Where edge distances are critical, and intersection with steel reinforcement is likely, drill hole at 10-degree angle or less and use prebent reinforcing bars.

E. Adhesive:

1. Install in accordance with written manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspection (Plan) in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information on special inspection and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01 45 33, Special Inspection, Observation, and Testing.
2. Continuous inspection required where noted in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing and where concrete dowels are installed in overhead applications.
3. Periodic inspection required where continuous inspection is not specified.
4. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report including the following:
 - a. Product Description: Product name, rod diameter, and length.
 - b. Drill bit compliance.
 - c. Hole diameter, diameter, and depth and cleanliness.
 - d. Adhesive expiration date.
5. Verification of dowel installation in accordance with manufacturer's published instructions

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI):
 - a. 318, Building Code Requirements for Structural Concrete.
 - b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
 - c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
 2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
 3. American National Standards Institute (ANSI).
 4. ASTM International (ASTM):
 - a. A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A143, Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
 - c. A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - d. A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
 - e. A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
 - f. A380, Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - g. A385, Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
 - h. A563, Specification for Carbon and Alloy Steel Nuts.
 - i. A780, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - j. A967, Specification for Chemical Passivation Treatments for Stainless Steel Parts.
 - k. E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
 - l. F436, Specification for Hardened Steel Washers.
 - m. F468, Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.

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- n. F568M, Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.
 - o. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - p. F594, Specification for Stainless Steel Nuts.
 - q. F1554, Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
6. International Code Council Evaluation Service (ICC-ES):
- a. Evaluation Reports for Concrete and Masonry Anchors.
 - b. AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
 - c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
 - d. AC106, Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
 - e. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
 - f. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.
7. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
8. Specialty Steel Industry of North America (SSINA):
- a. Specifications for Stainless Steel.
 - b. Design Guidelines for the Selection and Use of Stainless Steel.
 - c. Stainless Steel Fabrication.
 - d. Stainless Steel Fasteners.

1.02 DEFINITIONS

- A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.
- B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.
- C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

- D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.
- E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.
- B. Informational Submittals:
 - 1. Concrete and Masonry Anchors:
 - a. Manufacturer's product description and installation instructions.
 - b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
 - c. Adhesive Anchor Installer Certification.
 - 2. Passivation method for stainless steel members.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program or equivalent.
 - 2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package stainless steel items in a manner to provide protection from carbon impregnation.

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- B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

- A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

- B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

- A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.

4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.
 5. Acceptable for use in potable water structures by NSF 61.
- B. Torque-Controlled Expansion Anchors (Wedge Anchors):
1. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
 - b. DeWalt Anchors & Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).
 - d. “Or-Equal.”
- C. Self-Tapping Concrete Screw Anchors:
1. Manufacturers and Products:
 - a. DeWalt Anchors & Fasteners, Brewster, NY; Screw-Bolt+ (ESR-3889).
 - b. DeWalt Anchors & Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
 - c. DeWalt Anchors & Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
 - d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
 - e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).
 - f. “Or-Equal.”
- D. Adhesive Anchors:
1. Threaded Rod:
 - a. Diameter as shown on the Drawings.
 - b. Length as required to provide minimum depth of embedment indicated and thread projection required.
 - c. Clean and free of grease, oil, or other deleterious material.
 2. Adhesive:
 - a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
 - b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
 3. Packaging and Storage:
 - a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.

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- b. Store adhesive on pallets or shelving in a covered storage area.
 - c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
 - d. Dispose of When:
 - 1) Shelf life has expired.
 - 2) Stored other than in accordance with manufacturer's instructions.
4. Manufacturers and Products:
- a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 (ESR-3187).
 - b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-3G Epoxy Adhesive Anchors (ESR-4057), or AT-XP Adhesive Anchors (IAPMO UES-263).
 - c. DeWalt Anchors & Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).
 - d. "Or-Equal."
- E. Adhesive Threaded Inserts:
- 1. Type 316 stainless steel, internally threaded inserts.
 - 2. Manufacturer and Product:
 - a. Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.
 - b. "Or-Equal."

2.03 POST-INSTALLED MASONRY ANCHORS

- A. General: AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of section.
- B. Current ICC Evaluation Report indicating acceptance for anchors at structural applications in masonry.
- C. Manufacturers and Products:
 - 1. Hilti, Inc., Tulsa, OK; Kwik-Bolt-3 (KB-3) (ESR-1385), for grout-filled masonry, HIT-HY 70 (ESR-2682) for grout filled CMU, hollow CMU, or unreinforced masonry.
 - 2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU.

3. DeWalt Anchors & Fasteners, Brewster NY; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Screw-Bolt+ (ESR-4042) for grout-filled masonry.
4. “Or-Equal.”

PART 3 EXECUTION

3.01 CONCRETE AND MASONRY ANCHORS

- A. Begin installation only after concrete or masonry to receive anchors has attained design strength.
- B. Locate existing reinforcing with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing.
- C. Install in accordance with written manufacturer’s instructions.
- D. Provide minimum embedment, edge distance, and spacing as indicated on the Drawings.
- E. Use only drill type and bit type and diameter recommended by anchor manufacturer.
- F. Clean hole of debris and dust per manufacturer’s requirements.
- G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer’s installation instructions to clear obstruction, notify Engineer for direction on how to proceed.
- H. Adhesive Anchors:
 1. Unless otherwise approved by Engineer and adhesive manufacturer:
 - a. Do not install adhesive anchors when temperature of concrete or masonry is below 40 degrees F or above 100 degrees F.
 - b. Do not install prior to concrete attaining an age of 21 days.
 - c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
 - d. Do not disturb anchor during recommended curing time.
 - e. Do not exceed maximum torque as specified in manufacturer’s instructions.
 2. For hollow-unit masonry, install screen tube in accordance with manufacturer’s instructions.

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3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

- A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.
- B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.03 MANUFACTURER’S SERVICES

- A. Adhesive and Mechanical Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

- A. Unless indicated otherwise on the Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
All service uses and locations	Stainless steel adhesive anchors	Verify product acceptability and manufacturer’s requirements if anchor installation will occur in an overhead application
2. Anchors in Grout-Filled Concrete Masonry Units		
All service uses and locations	Stainless steel adhesive anchors	
3. Anchors in Hollow Concrete Masonry Units		
All service uses and locations	Stainless steel adhesive anchors	Adhesive anchors shall be installed with screen tubes.
4. All Others		
All service uses and locations	Stainless steel fasteners	

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- B. Antiseizing Lubricant: Use on all stainless steel threads.
- C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. BPVC SEC V, Nondestructive Examination.
 - b. BPVC SEC IX, Welding and Brazing Qualifications.
 2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
 3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
 4. American Welding Society (AWS):
 - a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - b. A3.0, Standard Welding Terms and Definitions.
 - c. D1.1/D1.1M, Structural Welding Code—Steel.
 - d. D1.8/D1.8M, Structural Welding Code—Seismic Supplement.
 - e. D1.2/D1.2M, Structural Welding Code—Aluminum.
 - f. D1.3/1.3M, Structural Welding Code—Sheet Steel.
 - g. D1.4/D1.4M, Structural Welding Code—Reinforcing Steel.
 - h. D1.6/D1.6M, Structural Welding Code—Stainless Steel.
 - i. QC1, Standard for AWS Certification of Welding Inspectors.

1.02 DEFINITIONS

- A. CJP: Complete Joint Penetration.
- B. CWI: Certified Welding Inspector.
1. Contractor's Welding Inspector: Contractor's CWI acts for, and on behalf of, the Contractor for all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes. This type of Quality Control Inspection is not classified as Special Inspection.

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2. Verification Inspector: This independent inspection is the prerogative of the Owner, who may employ their own, independent CWI, or waive this supplementary, independent CWI inspection.
- C. MT: Magnetic Particle Testing.
- D. NDE: Nondestructive Examination.
- E. NDT: Nondestructive Testing.
- F. PJP: Partial Joint Penetration.
- G. PQR: Procedure Qualification Record.
- H. PT: Liquid Penetrant Testing.
- I. Special Inspection: Nondestructive examination including MT, PT, UT, and RT. Special Inspection personnel report to, and are retained by the Owner or Engineer on behalf of the Owner. See additional requirements in Section 01 45 33, Special Inspection, Observation, and Testing.
- J. RT: Radiographic Testing.
- K. UT: Ultrasonic Testing.
- L. VT: Visual Inspection/Testing.
- M. WPQ: Welder/Welding Operator Performance Qualification Record.
- N. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

- A. Action Submittals:
 1. Shop Drawings:
 - a. Shop and field WPSs and PQRs.
 - b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
 - c. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
 - 1) Show on Shop Drawings, or on a weld map, complete information regarding base metal ASTM specifications, and location, type, size, and length of all welds.
 - 2) Identify WPS to be used, and NDE requirements in tail of welding symbols as indicated in AWS A2.4.

- 3) Clearly distinguish between shop and field welds.
- 4) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
- 5) Welding and NDE Symbols shall be in accordance with AWS A2.4. Welding terms and definitions shall comply with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency personnel credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms provided in referenced welding codes.

1.04 QUALIFICATIONS

- A. WPSs: In accordance with AWS D1.1/D1.1M (Annex J Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.
- B. WPQs: In accordance with AWS D1.1/D1.1M (Annex J Forms); or ASME BPVC SEC IX (Form QW-484).
- C. CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require prior approval by Engineer.
- D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05 SEQUENCING AND SCHEDULING

- A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

- A. Contractor's CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:
1. Verify conformance of specified job materials and proper storage.
 2. Monitor conformance with approved WPSs.
 3. Monitor conformance of WPQs.
 4. Inspect weld joint fit-up and perform in-process inspections.
 5. Provide 100 percent visual inspection of completed welds.
 6. Coordinate with nondestructive testing personnel and review NDE results.
 7. Maintain records and prepare reports documenting that results of CWI VT and required NDE complies with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

- A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

- A. Quality Control Inspection:
1. All Welds: 100 percent VT by Contractor's CWI.
 2. Acceptance Criteria:
 - a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 10.24.
 - b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - c. Stud Connections: AWS D1.1/D1.1M, Paragraph 9.8.1.
- B. Nondestructive Testing Requirements:
1. NDT frequency shall be as specified below, as required by referenced welding codes, or as specified in the attached table. In case there is a conflict, the higher frequency level of NDT shall apply.
 - a. Nontubular Connections:
 - 1) CJP Butt Joint Groove Welds: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.

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- 2) All Other CJP Groove Welds: 10 percent random UT.
- 3) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
- b. Tubular Connections:
 - 1) CJP butt joint groove welds made from one side without backing: 100 percent RT or UT in accordance with AWS D1.1/D1.1M, Paragraph 10.25.2 requirements.
 - 2) CJP Butt Joint Groove Welds made with back-gouging: 10 percent random RT.
 - 3) CJP Butt Joint Groove Welds made with backing and other butt joint groove welds that cannot be readily radiographed: 10 percent random UT.
 - 4) All Other CJP Groove Welds: 10 percent random UT.
 - 5) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
2. NDT Procedures and Acceptance Criteria:
 - a. Nontubular Connections:
 - 1) RT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part E. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.12.1.
 - 2) UT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part F. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.13.1.
 - 3) PT and MT:
 - a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
 - b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - b. Tubular Connections:
 - 1) RT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.27 and Paragraph 10.28.
 - 2) UT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.26, and Paragraph 10.29.
 - 3) PT and MT:
 - a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
 - b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 10.24.

3.03 FIELD QUALITY CONTROL

- A. The Contractor's CWI shall be present whenever field welding is being done and shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:
1. Verify conformance of specified job materials and proper storage.
 2. Monitor conformance with approved WPS.
 3. Monitor conformance of WPQ.
 4. Inspect weld joint fit-up and perform in-process inspection.
 5. Provide 100 percent visual inspection of all welds in accordance with Paragraph Quality Control Inspection.
 6. Coordinate with nondestructive testing personnel and review test results.
 7. Maintain records and prepare reports confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

- A. Repair and retest rejectable weld defects until sound weld metal have been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

- A. The supplement listed below, following "End of Section," is a part of this Specification.
1. Welding and Nondestructive Testing Table.

END OF SECTION

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Welding and Nondestructive Testing						
Specification Section	Governing Welding Codes or Standards	Submit WPS	Submit WPQ	Onsite CWI Required?	Submit Written NDT Procedure Specifications	NDT Requirements
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum or AWS D1.6/D1.6M, Structural Welding Code—Stainless Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 50 00
05 53 00 Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum	No	No	No	No	100% VT; also see Section 05 53 00
40 27 00 Process Piping— General	ASME BPV Code, Section IX; and ASME B31.3 Normal Fluid Service Category	Yes	Yes	Yes	Yes	100% VT and 5% RT; also see Section 40 27 00

SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
 2. American Galvanizers Association (AGA):
 - a. Inspection of Hot-Dip Galvanized Steel Products.
 - b. Quality Assurance Manual.
 3. American Iron and Steel Institute (AISI): Stainless Steel Types.
 4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
 5. American National Standards Institute (ANSI).
 6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
 7. American Welding Society (AWS):
 - a. D1.1/D1.1M, Structural Welding Code - Steel.
 - b. D1.2/D1.2M, Structural Welding Code - Aluminum.
 - c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
 8. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A48/A48M, Specification for Gray Iron Castings.
 - c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
 - g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

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- j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- k. A276, Standard Specification for Stainless Steel Bars and Shapes.
- l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
- m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
- n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
- o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
- p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
- q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
- r. A489, Standard Specification for Carbon Steel Lifting Eyes.
- s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
- t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
- u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
- v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
- y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
- z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- aa. A992/A992M, Standard Specification for Structural Steel Shapes.
- bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
- cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

- ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 - ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
 - gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
 - ii. F436, Standard Specification for Hardened Steel Washers.
 - jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
 - kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - ll. F594, Standard Specification for Stainless Steel Nuts.
 - mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
 - nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
 - oo. F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- 9. International Code Council (ICC): International Building Code (IBC) 2018.
 - 10. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
 - 11. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.27, Fixed Ladders.
 - b. 29 CFR 1926.105, Safety Nets.
 - c. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
 - 12. Specialty Steel Industry of North America (SSINA):
 - a. Specifications for Stainless Steel.
 - b. Design Guidelines for the Selection and Use of Stainless Steel.
 - c. Stainless Steel Fabrication.
 - d. Stainless Steel Fasteners.

1.02 DEFINITIONS

- A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.
- B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.
- C. Exterior Area: Location not protected from weather by building or other enclosed structure.

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- D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.
- E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.
- F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 DESIGN REQUIREMENTS

- A. Structural Performance of Aluminum Components and Associated Connectors, Fasteners and Anchors: Design, test, fabricate and install aluminum components and associated connectors, fasteners and anchors in accordance with the design requirements provided in Section 01 61 00, Common Product Requirements and herein. Aluminum components and associated connectors, fasteners and anchors shall be designed by a qualified professional engineer registered in state where Project will be constructed.
 - 1. Member sizes shown on the Drawings are minimum weights and stiffnesses. Final member sizes shall be determined by Contractor's qualified professional engineer.
 - 2. Grating shall not be used to provide diaphragm capacity or compression flange bracing.
 - 3. Design spandrel beams and their connections to resist out-of-plane lateral forces and torsion from railing, in addition to resisting gravity and lateral forces.
 - 4. Provide horizontal and diagonal bracing to prevent sidesway deflection.
 - 5. Maximum vertical live load deflection: 1/240 of span.
 - 6. Maximum horizontal deflection: 1/180 of span.
- B. Structural Performance of Pipe Supports: See Specification Section 40 05 15, Piping Support Systems.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings: Metal fabrications, including welding and fastener information.
 - 2. Product data sheets.

B. Informational Submittals:

1. Pre-engineered Ships Ladders: Letter of certification that ships ladder meets OSHA 29 CFR 1910.25 requirements. 2018 IBC and specifications herein; sealed signed and dated by a registered civil or structural Engineer licensed in state where Project will be constructed.
2. Passivation method for stainless steel members.
3. Calculations of Aluminum Components and Associated Connectors, Fasteners and Anchors: Complete design calculations for member stresses, deflections, connections and anchorage to resist gravity and lateral loads.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Shop Drawings for aluminum components and associated connectors, fasteners and anchors shall be sealed, signed and dated by a registered civil or structural engineer licensed in state where Project will be constructed.
2. Calculations for aluminum components and associated connectors, fasteners and anchors shall be sealed, signed and dated by a registered civil or structural engineer licensed in state where Project will be constructed.
3. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.
- B. Package stainless steel items to provide protection from carbon impregnation.
- C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.
- D. Store fabricated items in dry area, not in direct contact with ground.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500/A500M, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C or A1085
Aluminum:	
Aluminum Plates	B209, Alloy 6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes – Rolled	A276, AISI Type 304 (304L for welded connections)
Shapes – Built-Up	A276, AISI Type 304 (304L for welded connections) and A1069 (Laser-fused process)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition CW
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	F3125, Type I bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 55, with weldability supplement S1.
Eyebolts	A489

Item	ASTM Reference
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grades C-1010 through C-1020
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

- B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

- A. Cast-In-Place Anchor Bolts:
1. Headed type, unless otherwise shown on the Drawings.
 2. Material type and protective coating as shown in Fastener Schedule at end of this section.
- B. Anchor Bolt Sleeves:
1. Plastic:
 - a. Single unit construction with corrugated sleeve.
 - b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
 - c. Material: High-density polyethylene.
 2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

- A. See Section 05 05 19, Post-Installed Anchors.

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2.04 PIPE SLEEVES

- A. ASTM A53/A53M, Schedule 40 steel pipe sleeves with continuously welded 3/16-inch-thick seep ring with outside diameter 3 inches greater than sleeve outside diameter. Hot-dip galvanize in accordance with ASTM A123/A123M.

2.05 EMBEDDED STEEL SUPPORT FRAMES FOR GRATING

- A. Steel angle support frames to be embedded in concrete shall be stainless steel, ASTM A276, AISI Type 316, unless indicated otherwise.
- B. Welded anchors for stainless steel support frames shall also be stainless steel.

2.06 ABRASIVE NOSING FOR STAIRS

- A. Unless otherwise shown on the Drawings, furnish flush type abrasive nosings on stairs.
- B. Nosing Components:
 - 1. Homogeneous epoxy abrasive, with minimum 50 percent aluminum oxide content, formed and cured upon an extruded aluminum base.
 - 2. Epoxy abrasive shall extend over and form curved front edge of nosing.
 - 3. Base of Nosing: Extruded aluminum alloy, 6063-T5, heat-treated.
- C. Anchoring System: Double-set anchors consisting of two rows of integrally extruded anchors.
- D. Size: 3 inches wide by 1/4 inch to 3/8 inch thick by length as shown.
- E. Color: Selected by Engineer from manufacturer's standard color range.
- F. Manufacturers and Products:
 - 1. Wooster Products, Inc., Wooster, OH; Spectra Type WP3C.
 - 2. American Safety Tread Co., Inc., Helena, AL; Type FA-311D.
 - 3. "Or-Equal."

2.07 SHIPS LADDERS

- A. Fabricate ships ladders with stringers, railing, treads and cross-over platform to meet applicable requirements of OSHA, 29 CFR 1910.25, and IBC.
 - 1. Uniform load of 100 pounds per square foot.
 - 2. Concentrated load of 300 pounds loads imposed by persons occupying ships ladder shall be considered to be concentrated at such points as will cause maximum stress in structural member being considered.

3. Uniform and concentrated loads do not need to be applied concurrently.
4. Weight of ships ladder and attached appurtenances together with live load shall be considered in design of components, connections and anchorage.
5. Railing loads shall be in accordance with Section 05 52 16, Aluminum Railings.

B. Degree of Incline from Horizontal: As indicated on the Drawings.

C. Components:

1. Framing: Aluminum ASTM B632/B632M, Alloy 6061-T6.
2. Treads: Aluminum as specified in Section 05 53 00, Metal Gratings.
3. Railing: As specified in Section 05 52 16, Aluminum Railing.
4. Anchorage: As specified in Section 05 05 19, Post-Installed Anchors.
5. Bolts: Minimum 1/2-inch stainless steel.
6. Risers: Equally spaced to within 3/16-inch of adjacent risers.
7. Finish: Anodized.

2.08 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
 - a. Bostik, Middleton, MA; Neverseez.
 - b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.
 - c. "Or-Equal."

B. Elastomeric Bearing Pads:

1. Plain elastomeric bearing pad material, suitable for pipe support applications to reduce and dampen pipe vibrations.
2. Thickness: Minimum 1-inch.
3. Shore A Hardness: Minimum 50.

2.09 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.

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4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer's instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.

2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
 3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
 4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
 5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
 6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
 7. Galvanized steel sheets in accordance with ASTM A653/A653M.
 8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.
- F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
- G. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.
- H. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.10 SOURCE QUALITY CONTROL

- A. Visually inspect all fabrication welds and correct deficiencies:
1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
 2. Aluminum: AWS D1.2/D1.2M.
 3. Stainless Steel: AWS D1.6/D1.6M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

- A. General:
1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.

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2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer's recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

3.02 CAST-IN-PLACE ANCHOR BOLTS

- A. Locate and hold anchor bolts in place with templates at time concrete is placed.
- B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.
- C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 ABRASIVE NOSINGS

- A. Provide abrasive nosings on concrete steps not being supplied or coated with another type of nosing or nonskid material.

3.04 ELASTOMERIC BEARING PAD

- A. Install in accordance with manufacturer's written instructions. Use adhesive to bond to concrete surface.

3.05 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

C. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

3.06 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

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- C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.07 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

- A. Owner-Furnished Quality Assurance:

1. In accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing.
2. Contractor responsibilities and related information on special inspection, observation, and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

- B. Contractor-Furnished Quality Control:

1. Inspection and testing required in Section 01 45 16.13, Contractor Quality Control.
2. Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements and Section 01 88 15, Anchorage and Bracing.

3.08 FASTENER SCHEDULE

- A. Unless indicated otherwise on the Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Exterior and Interior Areas	Stainless steel headed anchor bolts	
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Exterior and Interior Areas	Stainless steel headed anchor bolts	
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		

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Service Use and Location	Product	Remarks
4. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
5. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
 2. American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete.
 3. American Iron and Steel Institute (AISI).
 4. ASTM International (ASTM):
 - a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - c. E894, Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
 - d. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
 - e. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
 5. International Code Council (ICC): 2018 International Building Code (IBC).
 6. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

- A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.
- B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.
- C. Special Inspection: As defined by the ICC IBC.

- D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

1.03 DESIGN REQUIREMENTS

- A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.
 - 1. Guardrail and Handrail: Capable of withstanding the following load cases applied:
 - a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
 - b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
 - c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
 - 2. In-Fill Area of Railing Systems:
 - a. Capable of withstanding a horizontally applied normal load of 50 pounds applied to 1 square foot at any point in system including panels, intermediate rails, balusters, and openings and space between railings.
 - b. Horizontal concentrated load need not be assumed to act concurrently with loads on top rails of railings.
 - 3. Calculated lateral deflection at top of posts shall not exceed 1 inch.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings:
 - a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
 - b. Manufacturer's literature and catalog data of railing and components.
 - c. Design Data: Calculations or test data using specified design performance loads and including the following:
 - 1) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
 - 2) Design of post base connection.

- 3) Documentation that concrete anchors have been designed in accordance with one of the following:
 - a) ACI 318, Chapter 17.
 - b) ICC Evaluation Services Report for selected anchor.
 2. Samples:
 - a. Rail sections, 6 inches long showing each type of proposed connection, proposed finish, and workmanship.
 - b. Each fitting including wall brackets, castings, toeboard, and rail expansion joints.
- B. Informational Submittals:
1. Manufacturer's assembly and installation instructions.
 2. Special Inspection: Manufacturer's instructions for Special Inspection of post-installed anchors.
 3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
 - a. Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
 - 1) Railing and post connections.
 - 2) Railing wall connections.
 - 3) Railing expansion joint connections.
 - 4) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.
 - b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
 - c. Deflection Criteria: In accordance with ASTM E985 and design loads specified, except as follows: maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
 - d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
 4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

1.05 QUALITY ASSURANCE

- A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to the extent possible until railing is completely installed.
- B. Delivery:
 - 1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
 - 2. Deliver toeboards loose for field assembly.
 - 3. Deliver clear anodized railing pipe and posts with protective plastic wrap.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and installation of railings to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperature of material as a result of both solar heat gain and night time sky heat loss. Temperature change is difference between high or low temperature and installation temperature.
 - 1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

- A. General:
 - 1. Furnish pre-engineered and prefabricated railing systems as shown on the Drawings.
 - 2. Railing systems using pop rivets or glued railing construction are not permitted.
 - 3. Sand cast accessories and components are not permitted.
 - 4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.
- B. Rails, Posts, and Formed Elbows:
 - 1. Extruded Alloy 6105-T5, 6061-T6, or equivalent.
 - 2. Tensile Strength: 38,000 psi, minimum.
 - 3. Yield Strength: 35,000 psi, minimum.

4. Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
 - a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
 - b. Gauge metal components are not acceptable for load-resisting components.
 - c. Fittings shall match color of pipe in railings.
2. Miscellaneous Extruded Aluminum Parts: Alloys 6063-T6, 6061-T6, or 6105 T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
 - a. Cast Al-mag with sufficient strength to meet load and test requirements.
 - b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.
4. Post Anchorages:
 - a. Refer to standard details for types of post anchorages and minimum requirements.
 - b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 316 stainless steel bolts or concrete anchors.
6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Railing System Gate:
 - a. Extruded aluminum rail components.
 - b. Hardware Manufacturers and Products:
 - 1) Julius Blum & Co., Inc., Carlstadt, NJ; No. 782/3 gate hinges with springs, and No. 784 gate latch and stop.
 - 2) CraneVeyor Corp., South El Monte, CA; No. C4370b gate hinges with spring, No. C4369 gate latch, and No. C4368 gate stop.
 - 3) Moultrie Manufacturing Co., Moultrie, GA; Part No. W60006.
 - 4) "Or-Equal."
8. Toeboards:
 - a. Molded or extruded Alloy 6063-T6 or 6061-T6 aluminum.
 - b. Provide slotted holes for expansion and contraction where required.
9. Fasteners: Stainless steel.

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D. Metal Supports Embedded in Concrete: In accordance with Section 05 50 00, Metal Fabrications.

E. Finishes:

1. Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 316.
2. Post-installed anchors in accordance with Section 05 50 00, Metal Fabrications, unless otherwise specified herein.
3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
 - a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
 - b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

- C. Shop Assembly:
 - 1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
 - 2. Fit dowels tightly inside posts.
- D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

- A. Field fabrication of aluminum railing systems is not permitted.
- B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.
- C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.
- D. Modification to supporting structure is not permitted where railing is to be attached.
- E. Mount railings only on completed surfaces. Do not support railings temporarily by means not satisfying structural performance requirements.
- F. Protection from Entrapped Water:
 - 1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.
 - 2. For posts mounted in concrete, bends, and elbows occurring at low points, drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

- A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.
- B. Expansion Joints:
 - 1. Maximum intervals of 54 feet on center and at structural joints.
 - 2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.

3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

C. Posts and Rails:

1. Surface Mounted Posts:
 - a. Bolt post baseplate connectors firmly in place.
 - b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Set posts plumb and aligned to within 1/8 inch in 12 feet.
3. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
4. Install posts and rails in same plane.
5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets: Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.

F. Railing System Gate: Install in accordance with manufacturer's installation instructions.

3.03 FIELD FINISHING

- A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

- A. Post-installed anchors supporting railing systems require special inspection.
- B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.
- C. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.05 CLEANING

- A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.
- B. Do not use acid solution, steel wool, or other harsh abrasive.
- C. If stain remains after washing, restore in accordance with railing manufacturer's recommendations or replace stained railings.

END OF SECTION

SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - d. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 3. National Association of Architectural Metal Manufacturers (NAAMM):
 - a. MBG 531, Metal Bar Grating Manual.
 - b. MBG 532, Heavy-Duty Metal Bar Grating Manual.

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
 - b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
 - c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
 - d. Manufacturer's specifications, including coatings, surface treatment, and finishes.
- B. Informational Submittals:
1. Special handling and storage requirements.
 2. Installation instructions.

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1.03 DELIVERY, STORAGE, AND HANDLING

- A. Insofar as is practical, factory assemble items.
- B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 - 1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
 - 2. HARSCO Industrial IKG, Houston, TX.
 - 3. Ohio Gratings, Inc., Canton, OH.
 - 4. “Or-Equal.”

2.02 GRATING MATERIALS

- A. Aluminum: Provide alloy and temper as designated below.
 - 1. Bearing Bars and Banding: ASTM B221 alloy 6061-T6 or 6063-T6.
 - 2. Swaged Crossbar Rods: ASTM B221 alloy 6061 or 6063, or ASTM B210 alloy 3003.
 - 3. Finish: Mill.

2.03 METAL BAR GRATING

- A. General Requirements:
 - 1. Maximum Service Load:
 - a. Light Duty (Type A): 100 psf uniformly distributed load.
 - 2. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
 - 3. Bearing Bar Spacing:
 - a. Light Duty: 1-3/16 inch maximum, center-to-center.
 - 4. Cross Bar Spacing: 4 inches maximum, center-to-center.
 - 5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on the Drawings.
- B. Grating Materials:
 - 1. Aluminum, pressure-locked I-bar grating fabricated by swaging crossbars between extruded I-shaped bearing bars.

- C. Surface: Striated.
- D. Stair Treads:
 - 1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
 - 2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
 - 3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 ACCESSORIES

- A. Embedded Frames: As indicated on the Drawings and as specified in Section 05 50 00, Metal Fabrications.
- B. Grating Clamps:
 - 1. Use at flanged beam and bolted angle frame supports.
 - 2. Removable from above grating walkway surface.
 - 3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
 - 4. Manufacturers and Products:
 - a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
 - b. Grating Fasteners, Inc., Harvey, LA; G-Clip.
 - c. “Or-Equal.”
- C. Anchor Stud and Saddle Clip:
 - 1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
 - 2. Removable from above grating walkway surface.
 - 3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.
 - 4. Manufacturers and Products:
 - a. Welded Stud Anchor:
 - 1) Nelson Stud Welding, Inc., Elyria, OH.
 - 2) Stud Welding Associates, Inc. Elyria, OH.
 - 3) “Or-Equal.”
 - b. Saddle Clip:
 - 1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
 - 2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
 - 3) Struct-Fast, Inc., Baltimore, MD; Gratefast.
 - 4) “Or-Equal.”

2.05 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Cutouts:
 - a. Fabricate in grating sections for penetrations indicated.
 - b. Arrange to permit grating removal without disturbing items penetrating grating.
 - c. Edge band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
6. Do not notch bearing bars at supports to maintain elevation.
7. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
8. Section Length: Sufficient to prevent section from falling through clear opening when oriented in the span direction and one end is touching either the concrete or the vertical leg of grating support.
9. Minimum Bearing: 1 inch for grating depth up to 2-1/4 inches and 2 inches for grating depth greater than 2-1/4 inches.
10. Banding and Toe Plates: Same material as grating and welded to bearing bars in accordance with requirements of NAAMM MBG 531 and NAAMM MBG 532.

B. Metal Bar Grating: A single grating section shall be not less than 1.5 feet or greater than 3 feet in width, or weigh more than 150 pounds.

C. Supports:

1. Same material as grating, except that supports which are to be embedded in concrete shall be Type 316 stainless steel, unless part of an extruded aluminum system.
2. Coordinate dimensions and fabrication with grating to be supported.

PART 3 EXECUTION

3.01 PREPARATION

- A. Electrolytic Protection:
1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09 90 00, Painting and Coating.
 2. Allow paint to dry before installation of material.

3.02 INSTALLATION

- A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in the area of potential fall hazard.
- B. Install manufactured products in accordance with manufacturer's recommendations.
- C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.
- D. Install grating supports plumb and level as applicable.
- E. Install sections of welded frames with anchors to straight plane without offsets.
- F. Field locate and install fasteners to fit grating layout.
- G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.
- H. Each grating or plank section shall be easily removable and replaceable.
- I. Completed installation shall be rigid and neat in appearance.
- J. Protect painted and galvanized surfaces during installation.
- K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Environmental Protection Agency (EPA).
 2. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
 3. Occupational Safety and Health Act (OSHA).
 4. The Society for Protective Coatings (SSPC):
 - a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
 - b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
 - c. SP 1, Solvent Cleaning.
 - d. SP 2, Hand Tool Cleaning.
 - e. SP 3, Power Tool Cleaning.
 - f. SP 5, White Metal Blast Cleaning.
 - g. SP 6, Commercial Blast Cleaning.
 - h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
 - i. SP 10, Near-White Blast Cleaning.
 - j. SP 11, Power Tool Cleaning to Bare Metal.
 - k. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
 - l. SP 13, Surface Preparation of Concrete.
 - m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.02 DEFINITIONS

- A. Terms used in this section:
1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
 2. FRP: Fiberglass Reinforced Plastic.
 3. HCl: Hydrochloric Acid.
 4. MDFT: Minimum Dry Film Thickness, mils.
 5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
 6. Mil: Thousandth of an inch.
 7. PDS: Product Data Sheet.

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8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:

a. Data Sheets:

- 1) For each product, furnish a Paint Product Data Sheet (PPDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PPDS form is appended to the end of this section.
- 2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
- 3) Technical and performance information that demonstrates compliance with specification.
- 4) Furnish copies of paint system submittals to the coating applicator.
- 5) Indiscriminate submittal of only manufacturer's literature is not acceptable.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
6. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

- A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.
- B. Regulatory Requirements:
 - 1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
 - 2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC PA 10.
 - c. Federal, state, and local agencies having jurisdiction.
- C. Mockup:
 - 1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
 - 2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Shipping:
 - 1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
 - 2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.
- B. Storage:
 - 1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
 - 2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

- A. Environmental Requirements: Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.
- B. Minimum of 5 years' verifiable experience in manufacture of specified product.
- C. Each of the following manufacturers is capable of supplying most of the products specified herein:
 - 1. Akzo Nobel.
 - 2. Carboline.
 - 3. PPG Industries.
 - 4. Sherwin Williams.
 - 5. TNEMEC.

2.02 PAINT MATERIALS

- A. General:
 - 1. Manufacturer's highest quality products suitable for intended service.
 - 2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
 - 3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.
- B. Products:

Product	Definition
Acrylic Latex	Latex
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately
Epoxy Primer— Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer— Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated

Product	Definition
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Novolac Vinyl Ester	Two-component, hybrid epoxy and polyester based resin, semi-gloss finish
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish

2.03 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.04 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:

- a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
- b. The surface preparation and application of the primer and finish coats shall be performed by pipe manufacturer.
- c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
- d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
- e. For conventional (alkyd) coatings, clean asphalt varnish supplied on pipe and apply one full coat of a tar stop before two full coats of the color coats specified.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.
- B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.
- C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

- A. Factory Finished Items:
 1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
 2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.
- B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

- A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.
- B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.
- C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.
- D. Mask openings in motors to prevent paint and other materials from entering.
- E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

- A. Metal Surface Preparation:
 - 1. Where indicated, meet requirements of SSPC Specifications summarized below:
 - a. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
 - 2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
 - 3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
 - 4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
 - 5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
 - 6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.

7. Welds and Adjacent Areas:
 - a. Prepare such that there is:
 - 1) No undercutting or reverse ridges on weld bead.
 - 2) No weld spatter on or adjacent to weld or any area to be painted.
 - 3) No sharp peaks or ridges along weld bead.
 - b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
- B. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:
 1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
 2. Brush blast in accordance with SSPC SP 16.
 3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.
- C. Concrete Surface Preparation:
 1. Do not begin until 30 days after concrete has been placed.
 2. Meet requirements of SSPC SP 13.
 3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
 4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
 5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
 6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

3.05 SURFACE CLEANING

- A. Brush-off Blast Cleaning:
 1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
 2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
 3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.

4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
 - a. Rate: Approximately 2 gallons per 100 square feet.
 - b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
 - c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
 - d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
 - e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
 - f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for existing and new, interior masonry, concrete, and metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise.

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2. Apply coatings in accordance with these Specifications and paint manufacturers' printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
3. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
4. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
5. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
6. Water-Resistant Gypsum Board: Use only solvent type paints and coatings.
7. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
8. Keep paint materials sealed when not in use.
9. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, such as Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
 - a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
 - a. Minimum required without regard to coating thickness.

- b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers’ products, and atmospheric conditions.
- 2. Application Thickness:
 - a. Do not exceed coating manufacturer’s recommendations.
 - b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
- 3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
 - a. Perform with properly calibrated instruments.
 - b. Recoat and repair as necessary for compliance with specification.
 - c. Coats are subject to inspection by Engineer and coating manufacturer’s representative.
- 4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
- 5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
- 6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

- A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.
- B. Additional requirements are included in the Piping Schedule.
- C. System No. 1 Interior UV Pipe Surfaces:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Tnemec Vinester 120-5002 Novolac Vinyl Ester Primer	1 coat, 12.0-18.0 MDFT
	Tnemec Vinester 120-5001 Novolac Vinyl Ester Finish Coat	1 coat, 12.0-18.0 MDFT

- 1. Use on the following items or areas:
 - a. Interior UV pipe surfaces where indicated on Process Mechanical Drawings.

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D. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer— Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
 - a. Exposed metal surfaces, new located inside or outside of structures and exposed to weather as indicated on the pipe schedule.

E. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
 - a. Galvanized surfaces requiring painting, and as specified in the Pipe Schedule
 - b. After application of System No. 10, apply finish coats as required for exposure.

3.08 ARCHITECTURAL PAINT SYSTEMS AND APPLICATION SCHEDULE

- A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. System No. 108 Masonry:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Masonry Surface Preparation or Existing Painted Surfaces to be Repainted Surface Preparation	Block Filler for existing unpainted masonry surfaces.	1 coat, 75 SFPG
	Acrylic Latex (Match existing paint sheen)	2 coats, 240 SFPGPC

1. Use on the following items or areas:
 - a. Existing interior masonry wall surfaces that require touchup painting due to damage or deterioration of existing paint or surfaces that were never painted and are now exposed due to removal of existing structure or equipment.
 - b. Color: Match existing interior wall coating.

C. System No. 121 Concrete, Skid-Resistant:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:
 - a. All surfaces of new concrete steps and landings.
 - b. Floor areas of existing equipment and supports that have been removed leaving exposed concrete.
2. Color: Match existing floor coating.

3.09 COLORS

- A. Provide as designated herein and shown in Piping Schedule.
- B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.
- C. Pipe Identification Painting:
 1. Pipe Color Coding: In accordance with Piping Schedule.

3.10 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.
2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

B. Testing:

1. Thickness and Continuity Testing:
 - a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
 - b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
 - c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
 - d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.11 CLEANUP

- A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.
- B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.
- C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.12 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are a part of this Specification:
 1. Paint System Data Sheet (PSDS).
 2. Paint Product Data Sheet (PPDS).

END OF SECTION

PAINT SYSTEM DATA SHEET

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	Product Name/Number (Proprietary)	Min. Coats, Coverage

PAINT PRODUCT DATA SHEET

Complete and attach manufacturer’s Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer’s recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer’s recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning: _____

Ambient Temperature Limitations: min.: _____ max.: _____

Surface Temperature Limitations: min.: _____ max.: _____

Surface Profile Requirements: min.: _____ max.: _____

Attach additional sheets detailing manufacturer’s recommended storage requirements and holiday testing procedures.

SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
 2. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Drawings showing layouts, actual letter sizes and styles, and Project-specific mounting details.
 - b. Manufacturer's literature showing letter sizes and styles, sign materials, and standard mounting details.
 2. Samples: One full size for each type of nameplate, sign, and label specified.
- B. Informational Submittals: Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 IDENTIFICATION LABELS

- A. Pipe Labels:
1. Snap-on, reversible type with lettering and directional arrows, sized for outside diameter of pipe and insulation.
 2. Provided with ties or straps for pipes of 6 inches and over diameter.
 3. Designed to firmly grip pipe so labels remain fixed in vertical pipe runs.
 4. Material: Heavy-duty vinyl or polyester, suitable for exterior use, long lasting, and resistance to moisture, grease, and oils.
 5. Letters and Arrows: Black on OSHA safety yellow background.
 6. Color Field and Letter Height: Meet ASME A13.1.
 7. Message: Piping system name as indicated on Piping Schedule.

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8. Manufacturers and Products:
 - a. Brady Signmark; B-915 BradySnap-On and Strap-On Pipe Markers.
 - b. Seton Identification Products; Ultra-mark Pipe Markers.
- B. Equipment Labels:
 1. Applies to equipment with assigned tag numbers, where specified.
 2. Letters: Black bold face, 3/4 inch minimum high.
 3. Background: OSHA safety yellow.
 4. Materials: Aluminum or stainless steel with a baked-on finish suitable for use on wet, oily, exposed, abrasive, and corrosive areas.
 5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.
 6. Size:
 - a. 2 inches minimum and 3 inches maximum high, by 14 inches minimum and 18 inches maximum long.
 - b. Furnish same size base dimensions for all labels.
 7. Message: Equipment names and tag numbers as used in sections where equipment is specified.
 8. Manufacturers:
 - a. Brady Signmark.
 - b. Seton Identification Products.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

- A. In accordance with manufacturer's recommendations.
- B. Mount securely, plumb, and level.

3.02 IDENTIFICATION LABELS

- A. Pipe Labels:
 1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
 2. At intervals along piping not greater than 18 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
 3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
 4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.

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5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

END OF SECTION

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
 2. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. Z535.4, Product Safety Signs and Labels.
 3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 4. UL.

1.03 DESIGN REQUIREMENTS

- A. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.
- B. Provide seismic certification per requirements of Section 01 45 33, Special Inspection, Observation, and Testing, where required in that section for electrical equipment listed.

1.04 SUBMITTALS

- A. Action Submittals:
1. Provide manufacturers' data for the following:
 - a. Nameplates, signs, and labels.
 2. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.
- B. Informational Submittals: Anchorage and bracing calculations, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

1.05 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.
- B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark or label.
- C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 ENVIRONMENTAL CONDITIONS

- A. The following areas are classified nonhazardous, wet, and corrosive. Use materials and methods required for such areas.
 - 1. Inside of a wet well.
 - 2. Within 10-foot envelope around lamp washdown area and UV Cleaning Station.
- B. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.
 - 1. Outdoor abovegrade areas not covered above.
 - 2. Equipment Room in UV Disinfection Building.
 - 3. Belowgrade vaults.
- C. The following areas are classified as indoor and dry:
 - 1. Electrical Room.
- D. The following areas are not classified. Use dust-tight and oil-tight NEMA 12 materials and methods.
 - 1. Areas not covered above.

PART 2 PRODUCTS

2.01 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.
- D. Equip panels installed outdoors in direct sun with sun shields.

2.02 EQUIPMENT FINISH

- A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in light gray color finish as approved by Engineer.

2.03 NAMEPLATES

- A. Material: Laminated plastic.
- B. Attachment Screws: Stainless steel.
- C. Color: White, engraved to a black core.
- D. Letter Height:
 - 1. Pushbuttons/Selector Switches: 1/8 inch.
 - 2. Other Electrical Equipment: 1/4 inch.

2.04 SIGNS AND LABELS

- A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

- A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.
- B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on the Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

- C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Keep openings in boxes and equipment closed during construction.
- E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING, BRACING, AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for Project design criteria provided in Section 01 61 00, Common Product Requirements, to meet the requirements of Section 01 88 15, Anchorage and Bracing.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.
- B. Homerun circuits shown on the Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:
 - 1. Analog control circuits from devices in same general area to same destination.
 - a. No power or ac discrete control circuits shall be combined in same conduit with analog circuits.
 - b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
 - c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
 - d. Raceways shall be sized per General Circuit and Raceway Schedule and do not exceed 40 percent fill.
 - e. Changes shall be documented on record drawings.
 - 2. Discrete control circuits from devices in the same general area to the same destination.
 - a. No power or analog control circuits shall be combined in same conduit with discrete circuits.

- b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
 - c. Raceways shall be sized per the General Circuit and Raceway Schedule and do not exceed 40 percent fill.
 - d. Changes shall be documented on record drawings.
3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
- a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - b. Receptacle Circuits, 120 Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

- 1. Field mark switchboards, motor control centers, panelboards to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.
- 2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from study required in Section 26 05 70, Electrical Systems Analysis as basis for warning signs.

B. Equipment Nameplates:

- 1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
- 2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
- 3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
- 4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

- A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
- B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.
- C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.
- B. Touchup Paint:
 - 1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
 - 2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.
- B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
 - b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
 2. Canadian Standards Association (CSA).
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
 4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. C12.1, Code for Electricity Metering.
 - c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
 - d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
 - f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 7. UL:
 - a. 98, Standard for Enclosed and Dead-Front Switches.
 - b. 248, Standard for Low Voltage Fuses.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 810, Standard for Capacitors.

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- g. 943, Standard for Ground-Fault Circuit-Interruption.
- h. 1059, Standard for Terminal Blocks.
- i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Provide manufacturers' data for the following:
 - a. Control devices.
 - b. Circuit breakers.
 - c. Fused switches.
 - d. Nonfused switches.
 - e. Fuses.
 - f. Intrinsic safety barriers.
 - g. Firestopping.
 - h. Enclosures: Include enclosure data for products having enclosures.
- 2. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

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

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

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

- 1. Type: Molded case.
- 2. Trip Ratings: 15 amps to 800 amps.
- 3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
- 4. Suitable for mounting and operating in any position.
- 5. UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two- and three-pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

D. Short Circuit Interrupting Ratings:

1. Not less than 65,000A RMS symmetrical for 480V equipment or 22,000A RMS symmetrical for 208/120V equipment.
2. Series Connected Ratings: Do not apply series connected short circuit ratings.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

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- H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
- I. Connections:
 - 1. Supply (line side) at either end.
 - 2. Mechanical wire lugs, except crimp compression lugs where shown.
 - 3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
 - 4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
 - 5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.
- J. Enclosures for Independent Mounting:
 - 1. See Article Enclosures.
 - 2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
 - 3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1.
- C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.
- D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- E. Connections:
 - 1. Mechanical lugs, except crimp compression lugs where shown.
 - 2. Lugs removable/replaceable.
 - 3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

- F. Fuse Provisions:
 - 1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
 - 2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
- G. Enclosures: See Article Enclosures.
- H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.
- D. Enclosures: See Article Enclosures.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

- A. Power Distribution, General:
 - 1. Current-limiting, with 200,000 ampere rms interrupting rating.
 - 2. Provide to fit mountings specified with switches.
 - 3. UL 248.
- B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
 - 1. Class: RK-1.
 - 2. Type: Dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
 - b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
- C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
 - 1. Class: L.
 - 2. Double O-rings and silver links.

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3. Manufacturers and Products:
 - a. Bussmann; Type KRP-C.
 - b. Littelfuse, Inc.; Type KLPC.
- D. Cable Limiters:
 1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
 2. Manufacturer and Product: Bussmann; K Series.
- E. Ferrule:
 1. 600V or less, rated for applied voltage, small dimension.
 2. Ampere Ratings: 1/10 amp to 30 amps.
 3. Dual-element time-delay, time-delay, or nontime-delay as required.
 4. Provide with blocks or holders as indicated and suitable for location and use.
 5. Manufacturers:
 - a. Bussmann.
 - b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- B. Selector Switch Operating Lever: Standard.
- C. Indicating Light: Push-to-test.
- D. Pushbutton Color:
 1. ON or START: Black.
 2. OFF or STOP: Red.
- E. Pushbutton and selector switch lockable in OFF position where indicated.
- F. Legend Plate:
 1. Material: Aluminum.
 2. Engraving: Enamel filled in high contrasting color.
 3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
 4. Letter Height: 7/64 inch.

- G. Manufacturers and Products:
 - 1. Heavy-Duty, Oil-Tight Type:
 - a. General Electric Co.; Type CR 104P.
 - b. Square D Co.; Type T.
 - c. Eaton/Cutler-Hammer; Type 10250T.
 - 2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
 - a. Square D Co.; Type SK.
 - b. General Electric Co.; Type CR 104P.
 - c. Eaton/Cutler-Hammer; Type E34.
 - d. Crouse-Hinds; Type NCS.

2.06 TERMINAL BLOCK, 600 VOLTS

- A. UL 486E and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.
- H. Terminals:
 - 1. Capable of wire connections without special preparation other than stripping.
 - 2. Capable of jumper installation with no loss of terminal or rail space.
 - 3. Individual, rail mounted.
- I. Marking system, allowing use of preprinted or field-marked tags.
- J. Manufacturers:
 - 1. Weidmuller, Inc.
 - 2. Ideal.
 - 3. Electrovert USA Corp.

2.07 SUPPORT AND FRAMING CHANNELS

- A. Carbon Steel Framing Channel:
 - 1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
 - 2. Finish: Hot-dip galvanized after fabrication.
- B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.
- C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.
- D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.
- E. Extruded Aluminum Framing Channel:
 - 1. Material: Extruded from Type 6063-T6 aluminum alloy.
 - 2. Fittings fabricated from Alloy 5052-H32.
- F. Nonmetallic Framing Channel:
 - 1. Material: Fire retardant, fiber reinforced vinyl ester resin.
 - 2. Channel fitting of same material as channel.
 - 3. Nuts and bolts of long glass fiber reinforced polyurethane.
- G. Manufacturers:
 - 1. B-Line Systems, Inc.
 - 2. Unistrut Corp.
 - 3. Aickinstrut.

2.08 FIRESTOPS

- A. General:
 - 1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
 - 2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
 - 3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by UL, or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.

2.09 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections:
 1. Except as shown otherwise, provide electrical enclosures according to the following table:

Enclosures			
Location	Finish	Environment	NEMA 250 Type
Indoor	Finished	Dry	1
Indoor	Unfinished	Dry	1
Indoor	Unfinished	Industrial Use	12
Indoor and Outdoor	Any	Wet	4
Indoor and Outdoor	Any	Denoted “WP”	3R
Indoor and Outdoor	Any	Wet and Corrosive	4X 316 Stainless Steel

PART 3 EXECUTION

3.01 GENERAL

- A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.
- B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.
- B. Channel Type:
 - 1. Interior, Wet or Dry (Noncorrosive) Locations:
 - a. Aluminum Raceway: Extruded aluminum or carbon steel with neoprene material isolators.
 - b. PVC-Coated Conduit: PVC coated.
 - c. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
 - 2. Interior, Corrosive (Wet or Dry) Locations:
 - a. Aluminum Raceway: Extruded aluminum.
 - b. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
 - 3. Outdoor, Noncorrosive Locations:
 - a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
 - b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel or carbon steel with neoprene material isolators.
 - 4. Outdoor Corrosive Locations:
 - a. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - b. Aluminum Raceway: Aluminum or carbon steel with neoprene material isolators.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.

5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.04 FIRESTOPS

- A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.
- B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
 2. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B3, Standard Specification for Soft or Annealed Copper Wire.
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
 - b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
 4. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
 5. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
 - e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

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6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. UL:
 - a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.
 - h. 1072, Standard for Safety for Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Standard for Safety for Metal-Clad Cables.
 - k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
 - a. Wire and cable.
 - b. Wire and cable accessories.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Factory Test Report for conductors 600 volts and below.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

- A. Conform to applicable requirements of NEMA WC 70.
- B. Conductor Type:
 1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
 2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
 3. All Other Circuits: Stranded copper.
- C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.
- D. Direct Burial and Aerial Conductors and Cables:
 1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
 2. Conform to physical and minimum thickness requirements of NEMA WC 70.
- E. Flexible Cords and Cables:
 1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
 2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 600-VOLT RATED CABLE

- A. General:
 1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 3. Suitable for installation in open air, in cable trays, or conduit.

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4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
 - a. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - 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	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
 - a. Okonite Co.
 - b. Southwire.

C. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 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.

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- b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
 - 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
- D. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
- 1. Outer Jacket: 45-mil nominal.
 - 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 - 3. Dimension: 0.32-inch nominal OD.
 - 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand, tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Triad conductors black, red, and blue.
 - 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
- E. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 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.

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2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

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

4. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

F. Type 6, 18 AWG, Multitwisted Pairs with Common Overall Shield
 Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
 - b. Tinned copper drain wire size AWG 18.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	45
8	0.63	60
12	0.75	60

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Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
16	0.83	60
24	1.10	80
36	1.21	80
50	1.50	80

3. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

2.03 SPECIAL CABLES

- A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
 1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
 5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
 6. Manufacturer and Product: Belden; 7852A.

2.04 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.
- B. Direct Buried: Bare stranded copper.

2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape:
 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.

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2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers and Products:
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
 - a. Chemical-resistant white tag.
 - b. Size: 1/2 inch by 2 inches.
 - c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - 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) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
 - 3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
 - 4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.
- D. Cable Lugs:
- 1. In accordance with NEMA CC 1.
 - 2. Rated 600 volts of same material as conductor metal.
 - 3. 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.
 - 4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
- E. Cable Ties:
- 1. Nylon, adjustable, self-locking, and reusable.
 - 2. Manufacturer and Product: Thomas & Betts; TY-RAP.
- F. Heat Shrinkable Insulation:
- 1. Thermally stabilized cross-linked polyolefin.
 - 2. Single wall for insulation and strain relief.

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3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.

2.06 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers:
 1. Ideal Co.
 2. Polywater, Inc.
 3. Cable Grip Co.

2.07 WARNING TAPE

- A. As specified in Section 26 05 33, Raceway and Boxes.

2.08 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

PART 3 EXECUTION

3.01 GENERAL

- A. Conductor installation shall be in accordance with manufacturer's recommendations.
- B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- D. Terminate conductors and cables, unless otherwise indicated.

- E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.
- F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.
- G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.
- H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

- 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
- 2. 8 AWG and Smaller: Provide colored conductors.
- 3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue

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System	Conductor	Color
480Y/277 Volts, Three-Phase, Four- Wire	Grounded Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

3.03 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.
- C. Circuits Not Appearing in Circuit Schedules:
 1. Assign circuit name based on device or equipment at load end of circuit.
 2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
- D. Method:
 1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
 2. Cables and Conductors 2 AWG and Larger:
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
 3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
 - b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

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H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over shield.

- I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Product data for the following:
 - 1) Exothermic weld connectors.
 - 2) Mechanical connectors.
 - 3) Compression connectors.
 - 4) Specialty tools.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL:
 - a. Confirm conformance with UL standards.
 - b. Supply with an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper.

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B. Diameter: Minimum 3/4 inch.

C. Length: 20 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers:
 - a. Erico Products, Inc. ; Cadweld and Cadweld Exolon.
 - b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
 - a. Burndy Corp.; Hyground Irreversible Compression.
 - b. Thomas and Betts Co.
 - c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
 - a. Burndy Corp.
 - b. Thomas and Betts Co.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast-iron riser ring and traffic cover marked “GROUND ROD”.

B. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Lightning and Grounding Systems, Inc.; I-R Series.

PART 3 EXECUTION

3.01 GENERAL

- A. Grounding: In compliance with NFPA 70 and IEEE C2.
- B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.
- C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.
- D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.
- E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.
- F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.
- G. Shielded Instrumentation Cables:
 - 1. Ground shield to ground bus at power supply for analog signal.
 - 2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
 - 3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

- A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.
- B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Connect ground conductors to raceway grounding bushings.
- D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.
- E. Connect enclosure of equipment containing ground bus to that bus.

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- F. Bolt connections to equipment ground bus.
- G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.
- H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.
- I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

- A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.
- B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.
- D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.
- E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

- A. Install full length with conductor connection at upper end.
- B. Install with connection point below finished grade, unless otherwise shown.
- C. Space multiple ground rods by one rod length.
- D. Install to 8 feet below local frost depth.

3.05 GROUNDING WELLS

- A. Install for ground rods located inside buildings, asphalt and paved areas, and where shown on the Drawings.
- B. Install riser ring and cover flush with surface.
- C. Place 8 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

- 1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
- 2. Belowgrade Connections: Install exothermic weld or compression type connectors.
- 3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
- 4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

- 1. Wire brush or file contact point to bare metal surface.
- 2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
- 3. Avoid using badly worn molds.
- 4. Mold to be completely filled with metal when making welds.
- 5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

- 1. Install in accordance with connector manufacturer's recommendations.
- 2. Install connectors of proper size for grounding conductors and ground rods specified.
- 3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

- 1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
- 2. Install in accordance with connector manufacturer's recommendations.
- 3. Do not conceal mechanical connections.

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3.07 METAL STRUCTURE GROUNDING

- A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.
- B. Bond electrical equipment supported by metal platforms to the platforms.
- C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

- A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.
- B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.
- C. Make connections of grounding conductors fully visible and accessible.
- D. Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

- A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.
- B. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 LIGHTNING PROTECTION SYSTEMS

- A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.11 SURGE PROTECTION EQUIPMENT GROUNDING

- A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
 4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - c. C80.3, Steel Electrical Metallic Tubing (EMT).
 - d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
 - e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
 - f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - k. VE 1, Metallic Cable Tray Systems.

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6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL:
 - a. 1, Standard for Safety for Flexible Metal Conduit.
 - b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
 - c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
 - d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
 - e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
 - g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
 - j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
 - k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
 - l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
 - m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
 - a. Rigid galvanized steel conduit.
 - b. PVC Schedule 40 conduit.
 - c. PVC-coated rigid galvanized steel conduit.
 - d. Flexible metal, liquid-tight conduit.
 - e. Flexible, nonmetallic, liquid-tight conduit.
 - f. Flexible metal, nonliquid-tight conduit.
 - g. Conduit fittings.
 - h. Wireways.
 - i. Large junction and pull boxes.
 - j. Terminal junction boxes.
2. Equipment and machinery proposed for bending metal conduit.
3. Method for bending PVC conduit less than 30 degrees.

4. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

- B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

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- C. PVC-Coated Rigid Galvanized Steel Conduit:
 - 1. Meet requirements of NEMA RN 1
 - 2. Material:
 - a. Meet requirements of NEMA C80.1 and UL 6.
 - b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
 - c. Interior finish: Urethane coating, 2-mil nominal thickness.
 - 3. Threads: Hot-dipped galvanized and factory coated with urethane.
 - 4. Bendable without damage to interior or exterior coating.

- D. Flexible Metal, Liquid-Tight Conduit:
 - 1. UL 360 listed for 105 degrees C insulated conductors.
 - 2. Material: Galvanized steel with extruded PVC jacket.

- E. Flexible Metal, Nonliquid-Tight Conduit:
 - 1. Meet requirements of UL 1.
 - 2. Material: Galvanized steel.

- F. Flexible, Nonmetallic, Liquid-Tight Conduit:
 - 1. Material: PVC core with fused flexible PVC jacket.
 - 2. UL 1660 listed for:
 - a. Dry Conditions: 80 degrees C insulated conductors.
 - b. Wet Conditions: 60 degrees C insulated conductors.
 - 3. Manufacturers and Products:
 - a. Carlon; Carflex or X-Flex.
 - b. T & B; Xtraflex LTC or EFC.

2.02 FITTINGS

- A. Rigid Galvanized Steel and Intermediate Metal Conduit:
 - 1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
 - 2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturers and Products:
 - 1) Appleton; Series BU-I.
 - 2) O-Z/Gedney; Type HB.

3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
 - b. Manufacturers and Products:
 - 1) Appleton; Series GIB.
 - 2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) Appleton, Series HUB-B.
 - 2) O-Z/Gedney; Series CH.
 - 3) Meyers; ST Series.
5. Conduit Bodies:
 - a. Sized as required by NFPA 70.
 - b. Manufacturers and Products (For Normal Conditions):
 - 1) Appleton; Form 35 threaded unilets.
 - 2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
 - 3) Killark; Series O electrolets.
 - 4) Thomas & Betts; Form 7 or Form 8.
 - c. Manufacturers (For Hazardous Locations):
 - 1) Appleton.
 - 2) Crouse-Hinds.
 - 3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
 - a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - 1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
 - 2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYF, EYM, or ESU.
 - 2) Crouse-Hinds; Type EYS or EZS.
 - 3) Killark; Type EY or Type EYS.
9. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYD.
 - 2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.

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11. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement:
 - a) Appleton; Type DF.
 - b) Crouse-Hinds; Type XD.
 - 2) Expansion Movement Only:
 - a) Appleton; Type XJ.
 - b) Crouse-Hinds; Type XJ.
 - c) Thomas & Betts; XJG-TP.
 12. Cable Sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:
 - 1) Appleton; CG-S.
 - 2) Crouse-Hinds; CGBS.
- B. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC 3.
 2. Type: PVC, slip-on.
- C. PVC-Coated Rigid Galvanized Steel Conduit:
1. Meet requirements of UL 514B.
 2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
 3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
 4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
 5. Overlapping pressure-sealing sleeves.
 6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
 7. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
 8. Expansion Fitting:
 - a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.
- D. Flexible Metal, Liquid-Tight Conduit:
1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
 2. Insulated throat and sealing O-rings.

3. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel or malleable iron.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
 - a. Carlon; Type LT.
 - b. O-Z/Gedney; Type 4Q-P.
 - c. Thomas & Betts; Series 6300.

G. Watertight Entrance Seal Device:

1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

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

B. Cast Metal:

1. Box: Malleable iron or Cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.

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3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or Type FD.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
6. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA or Type EAJ.
 - b. Appleton; Type GR.

C. Cast Aluminum:

1. Material:
 - a. Box: Cast, copper-free aluminum.
 - b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS-SA or Type FD-SA.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
5. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA-SA.
 - b. Appleton; Type GR.

D. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
 - a. Exterior Surfaces: 40-mil PVC.
 - b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.

E. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

2.04 JUNCTION AND PULL BOXES

- A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.
- B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.
- C. Large Sheet Steel Box:
 - 1. NEMA 250, Type 1.
 - 2. Box: Code-gauge, galvanized steel.
 - 3. Cover: Full access, screw type.
 - 4. Machine Screws: Corrosion-resistant.
- D. Large Stainless Steel Box:
 - 1. NEMA 250 Type 4X.
 - 2. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel, with white enamel painted interior mounting panel.
 - 3. Cover: Hinged with screws.
 - 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 - 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
- E. Large Steel Box:
 - 1. NEMA 250 Type 12.
 - 2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Engineer.
 - 3. Cover: Hinged with screws.
 - 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 - 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
- F. Concrete Box, Nontraffic Areas:
 - 1. Box: Reinforced, cast concrete with extension.
 - 2. Cover: Steel diamond plate with locking bolts.
 - 3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
 - 4. Size: 10 inches by 17 inches, minimum.

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5. Manufacturers and Products:
 - a. Utility Vault Co.; Series 36-1017.
 - b. Christy, Concrete Products, Inc.; N9.
 - c. Quazite; “PG” Style.

G. Concrete Box, Traffic Areas:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading with screw down.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Manufacturers and Products:
 - a. Christy, Concrete Products, Inc.; B1017BOX.
 - b. Utility Vault Co.; 3030 SB.

2.05 TERMINAL JUNCTION BOX

- A. Cover: Hinged, unless otherwise shown.
- B. Interior Finish: Paint with white enamel or lacquer.
- C. Terminal Blocks:
 1. Separate connection point for each conductor entering or leaving box.
 2. Spare Terminal Points: 25 percent, minimum.

2.06 METAL WIREWAYS

- A. Meet requirements of UL 870.
- B. Type: Steel-enclosed, lay-in type.
- C. Cover: Hinged with friction latch.
- D. Rating: Outdoor raintight.
- E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.
- F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
- G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.

2.07 NONMETALLIC WIREWAY

- A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.
- B. Type: Fiberglass-enclosed, with removable cover.
- C. Captivated, corrosion-resistant cover screws.
- D. Oil-resistant gaskets.
- E. Meet UL cold impact test to minus 35 degrees C.
- F. Manufacturer: Hoffman.

2.08 ACCESSORIES

A. Identification Devices:

1. Raceway Tags:
 - a. Material: Permanent, nonferrous metal.
 - b. Shape: Round.
 - c. Raceway Designation: Pressure stamped, embossed, or engraved.
 - d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
 - a. Material: Polyethylene, 4-mil gauge with detectable strip.
 - b. Color: Red.
 - c. Width: Minimum 6 inches.
 - d. Designation: Warning on tape that electric circuit is located below tape.
 - e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
 - f. Manufacturers and Products:
 - 1) Panduit; Type HTDU.
 - 2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
 - a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
 - b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.

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- c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.
- B. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.
- C. Heat Shrinkable Tubing:
 - 1. Material: Heat-shrinkable, cross-linked polyolefin.
 - 2. Semi-flexible with meltable adhesive inner liner.
 - 3. Color: Black.
 - 4. Manufacturers:
 - a. Raychem.
 - b. 3M.
- D. Wraparound Duct Band:
 - 1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
 - 2. Width: 50 mm minimum.
 - 3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

- A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.
- B. Comply with NECA Installation Standards.
- C. Crushed or deformed raceways not permitted.
- D. Maintain raceway entirely free of obstructions and moisture.
- E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- H. Group raceways installed in same area.

- I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- M. Install watertight fittings in outdoor, underground, or wet locations.
- N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.
- Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

- A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.
 - 1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
 - 2. Conduit is sized per the NEC.
 - 3. Conduit is of the type specified in Contract Documents.
 - 4. Conduit is supported as specified in Contract Documents.
- B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

- A. Minimum Cover: 2 inches, including fittings.
- B. Conduit placement shall not require changes in reinforcing steel location or configuration.
- C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
- D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.
- E. Slabs and Walls (Requires Engineer Approval):
 - 1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
 - 2. Install within middle two-fourths of slab or wall.
 - 3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
 - 4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
 - 5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
 - 6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
 - 7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.
- F. Columns and Beams (Requires Engineer Approval):
 - 1. Trade size of conduit not to exceed one-fourth of beam thickness.
 - 2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

- A. Diameter: Minimum 3/4 inch.
- B. Exterior, Exposed: PVC-coated rigid galvanized steel.
- C. Interior, Exposed:
 - 1. Rigid galvanized steel.
 - 2. PVC-coated rigid galvanized steel.
- D. Interior, Concealed (Not Embedded in Concrete): Rigid galvanized steel.

- E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors:
 - 1. PVC Schedule 40, except as noted in paragraph N.
- F. Direct Earth Burial: PVC-coated rigid galvanized steel.
- G. Concrete-Encased Ductbank: PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for dc circuits, except as noted in paragraph N.
- H. Under Slabs-On-Grade: PVC-coated rigid galvanized steel.
- I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.
- J. Under Equipment Mounting Pads: PVC-coated rigid steel conduit.
- K. Exterior Light Pole Foundations: PVC-coated rigid steel conduit.
- L. Corrosive Areas: PVC Schedule 40, except as noted in paragraph N.
- M. Hazardous Gas Areas: Rigid galvanized steel.
- N. All conduits that contain signal and communication (i.e. analog) cables shall be rigid galvanized steel. If conduit is direct buried, provide PVC-coated rigid galvanized steel conduit.

3.05 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:
 - 1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
 - 2. Conduit Size Over 4 Inches: Nonflexible.
 - 3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight.
 - 4. Dry Areas: Flexible, metallic liquid-tight.
 - 5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.
- B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

- D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.06 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- D. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.
- E. Entering Structures:
 - 1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
 - 2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal.
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side.
 - c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
 - 3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer.
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment.
 - c. Seal penetration with Type 5 sealant.
 - 4. Corrosive-Sensitive Areas:
 - a. Seal conduit passing through room walls.
 - b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
 - c. Seal penetration with Type 5.
 - 5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.

6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
 - a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
 - a. Metallic Raceways: Provide insulated grounding bushings.
 - b. Nonmetallic Raceways: Provide bell ends flush with wall.
 - c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 25 percent extra space for future conduit.
- C. Application/Type of Conduit Strap:
 1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
 2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
 3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.
- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 1. Wood: Wood screws.
 2. Hollow Masonry Units: Toggle bolts.
 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 4. Steelwork: Machine screws.
 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.
- E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

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- F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.08 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
- C. Install with symmetrical bends or cast metal fittings.
- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- G. PVC Conduit:
 - 1. Bends 30 Degrees and Larger: Provide factory-made elbows.
 - 2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
 - 3. Use manufacturer's recommended method for forming smaller bends.
- H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 EXPANSION/DEFLECTION FITTINGS

- A. Provide on raceways at structural expansion joints and in long tangential runs.
- B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.
- C. Install in accordance with manufacturer's instructions.

3.10 PVC CONDUIT

- A. Solvent Welding:
 - 1. Apply manufacturer recommended solvent to joints.
 - 2. Install in order that joint is watertight.
- B. Adapters:
 - 1. PVC to Metallic Fittings: PVC terminal type.
 - 2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.
- C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
- C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.
- C. Applications:
 - 1. Metal wireway in indoor dry locations.
 - 2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.13 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
- B. Nonmetallic, Cabinets, and Enclosures:
 - 1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
 - 2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

- C. Sheet Metal Boxes, Cabinets, and Enclosures:
1. General:
 - a. Install insulated bushing on ends of conduit where grounding is not required.
 - b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
 - c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
 - d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
 - e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
 2. Rigid Galvanized Conduit:
 - a. Provide one lock nut each on inside and outside of enclosure.
 - b. Install grounding bushing at source enclosure.
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
 3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
 4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
 5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
 6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

3.14 UNDERGROUND RACEWAYS

- A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
- B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.
- C. Make routing changes as necessary to avoid obstructions or conflicts.
- D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
- E. Union type fittings not permitted.

- F. Spacers:
 - 1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
 - 2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
- G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.
- H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.
- I. Installation with Other Piping Systems:
 - 1. Crossings: Maintain minimum 12-inch vertical separation.
 - 2. Parallel Runs: Maintain minimum 12-inch separation.
 - 3. Installation over valves or couplings not permitted.
- J. Metallic Raceway Coating: At couplings and joints apply wraparound duct band with one-half tape width overlap to obtain two complete layers.
- K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.
- L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.
- M. Backfill: Do not backfill until inspected by Engineer.

3.15 UNDER SLAB RACEWAYS

- A. Make routing changes as necessary to avoid obstructions or conflicts.
- B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.
- C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.
- D. Raceway spacing, in a single layer or multiple layers:
 - 1. 3 inches clear between adjacent 2-inch or larger raceway.
 - 2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

- E. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.
- F. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.
- G. Fittings:
 - 1. Union type fittings are not permitted.
 - 2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
 - 3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

- A. General:
 - 1. Install plumb and level.
 - 2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
 - 3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
 - 4. Install galvanized mounting hardware in industrial areas.
- B. Size:
 - 1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
 - a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
 - 2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
 - 3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.
- C. Locations:
 - 1. Drawing locations are approximate.
 - 2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.

3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
 - c. Do not straddle CMU block or other construction joints.
2. Light Switch:
 - a. 48 inches above floor.
 - b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Convenience Receptacle:
 - a. General Interior Areas: 15 inches above floor.
 - b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
 - c. Industrial Areas, Workshops: 48 inches above floor.
 - d. Outdoor Areas: 24 inches above finished grade.
5. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

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4. Provide plaster rings where necessary.
 5. Boxes embedded in concrete or masonry need not be additionally supported.
- G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.
- H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.

2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.
- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.19 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination.
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide noncorrosive wire for attachment.

3.20 PROTECTION OF INSTALLED WORK

- A. Protect products from effects of moisture, corrosion, and physical damage during construction.
- B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.
- D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI).
 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 - c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
 - d. 1584, Guide for Performing Arc Flash Hazard Calculations.
 3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
 4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70E, Standard for Electrical Safety in the Workplace.
 5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

1.02 SUBMITTALS

- A. Action Submittals:
1. Short circuit study.
 2. Protective Device Coordination Study: Submit within 90 days after approval of short circuit study.
 3. Arc Flash Study: Submit initial study with protective Device Coordination Study. Submit final study prior to equipment energization.
 4. Arc flash warning labels; submit sample with initial study.
 5. Electronic files of final studies including all engineering software input files, output reports, and libraries.

1.03 QUALITY ASSURANCE

- A. Short circuit and protective device coordination and arc flash studies shall be prepared by a professional electrical engineer registered in the State of Georgia.

1.04 SEQUENCING AND SCHEDULING

- A. Initial complete short circuit study shall be submitted and reviewed before Engineer will review Shop Drawings for electrical equipment .
- B. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.
- C. Initial complete arc flash study shall be submitted and accepted prior to energization of the electrical equipment.
- D. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 30 days before energizing electrical equipment.
- E. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.
- F. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

- A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on the Drawings.
- B. Perform studies using one of the following electrical engineering software packages:
 - 1. SKM Power Tools for Windows.
 - 2. ETAP.
 - 3. Paladin.
 - 4. Easy Power.
- C. Perform complete fault calculations for each proposed and ultimate source combination.
 - 1. Source combination may include present and future power company supply circuits, large motors, or generators.

- D. Utilize proposed and existing load data for study obtained from Contract Documents and obtained from extensive field investigation of system configuration, wiring information, and equipment. The Owner will make all existing documentation on the existing facility available to the Contractor for their use in the development of the specified studies. However, all the information required to perform the specified studies will not be contained within the existing documentation for the existing equipment currently installed. Therefore, the Contractor may be required to perform extensive field investigations to obtain any information that is not provided either by the Owner, Engineer, or the existing documentation available for this facility. All labor, materials, equipment, and incidental items required to obtain any information necessary to perform the specified studies shall be provided by the Contractor as part of his Bid.
- E. Existing System and Equipment:
 - 1. Extent of existing system to be included in study shall include all existing electrical equipment as well as all new electrical equipment. Include fault contribution of all existing, new, and future motors and equipment in study..
 - 2. Include fault contribution of existing motors and equipment in study.
 - 3. Include impedance elements that affect new system and equipment.
 - 4. Include protective devices in series with new equipment.
- F. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.
- G. Perform separate studies for both plants:
 - 1. W.J. Hopper WPP.
 - 2. Terry R. Hicks WPP.

1.06 SHORT CIRCUIT STUDY

- A. General:
 - 1. Prepare in accordance with IEEE 399.
 - 2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
 - 3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
 - 4. Use cable and bus resistances calculated at 25 degrees C.
 - 5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.

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6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN conductors.
 7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.
- B. Provide:
1. Calculation methods and assumptions.
 2. Typical calculation.
 3. Tabulations of calculated quantities.
 4. Results, conclusions, and recommendations.
 5. Selected base per unit quantities.
 6. One-line diagrams.
 7. Source impedance data, including electric utility system and motor fault contribution characteristics.
 8. Impedance diagrams.
 9. Zero-sequence impedance diagrams.
- C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:
1. Electric utility’s supply termination point.
 2. Main switchboard.
 3. Unit substation primary and secondary terminals.
 4. Low-voltage switchgear and switchboards.
 5. Motor control centers.
 6. Standby generators.
 7. Branch circuit panelboards.
 8. Future load contributions as shown on one-line diagram.
- D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.
- E. Provide bolted line-to-line fault current study for areas as defined for three-phase bolted fault short circuit study.
- F. Verify:
1. Equipment and protective devices are applied within their ratings.
 2. Adequacy of switchgear, switchboard, and motor control centers bus bars to withstand short circuit stresses.
 3. Adequacy of transformer windings to withstand short circuit stresses.
 4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

G. Tabulations:

1. General Data:
 - a. Short circuit reactances of rotating machines.
 - b. Cable and conduit material data.
 - c. Bus data.
 - d. Transformer data.
 - e. Circuit resistance and reactance values.
2. Short Circuit Data (for each source combination):
 - a. Fault impedances.
 - b. X to R ratios.
 - c. Asymmetry factors.
 - d. Motor contributions.
 - e. Short circuit kVA.
 - f. Symmetrical and asymmetrical fault currents.
3. Equipment Evaluation:
 - a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
 - b. Maximum fault current available.

H. Written Summary:

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

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

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

K. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
 - a. Provide separate curve sheets for phase and ground fault coordination for each scenario.

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- b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
- c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
- d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
- e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Electric utility's relays.
2. Electric utility's fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
3. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
4. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
5. Pertinent transformer full-load currents at 100 percent.
6. Transformer magnetizing inrush currents.
7. Transformer damage curves; appropriate for system operation and location.
8. ANSI transformer withstand parameters.
9. Significant symmetrical and asymmetrical fault currents.
10. Motor overload relay settings for motors greater than 40 hp.
11. Ground fault protective device settings.
12. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

C. Primary Protective Device Settings for Delta-Wye Connected Transformer:

1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer's characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.
2. Secondary Line-to-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

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

E. Tabulate Recommended Protective Device Settings:

1. Relays:
 - a. Current tap.
 - b. Time dial.
 - c. Instantaneous pickup.
 - d. Electronic settings data file.
 2. Circuit Breakers:
 - a. Adjustable pickups.
 - b. Adjustable time-current characteristics.
 - c. Adjustable time delays.
 - d. Adjustable instantaneous pickups.
 - e. I²t In/Out.
 - f. Zone interlocking.
 - g. Electronic settings data file.
- F. Written Summary:
1. Scope of studies performed.
 2. Summary of protective device coordination methodology.
 3. Prevailing conditions.
 4. Selected equipment deficiencies.
 5. Results of coordination study.
 6. Appendix of complete relay and circuit breaker electronic setting files , submit electronic data files from manufacturer's software.
 7. Comments or suggestions.

1.08 ARC FLASH STUDY

- A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.
- B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.
- C. Base Calculation: For each major part of electrical power system, determine the following:
 1. Flash hazard protection boundary.
 2. Limited approach boundary.
 3. Restricted approach boundary.
 4. Incident energy level.
 5. Glove class required.

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- D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.
1. Bus name.
 2. Bus voltage.
- E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:
1. Bus name.
 2. Upstream protective device name, type, and settings.
 3. Bus line-to-line voltage.
- F. Produce arc flash evaluation summary sheet listing the following additional items:
1. Bus name.
 2. Upstream protective device name, type, settings.
 3. Bus line-to-line voltage.
 4. Bus bolted fault.
 5. Protective device bolted fault current.
 6. Arcing fault current.
 7. Protective device trip/delay time.
 8. Breaker opening time.
 9. Solidly grounded column.
 10. Equipment type.
 11. Gap.
 12. Arc flash boundary.
 13. Working distance.
 14. Incident energy.
- G. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 40 cal/cm². Propose approaches to reduce energy levels.
- H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:
1. Equipment manufacturer's information used to prepare study.
 2. Assumptions made during study.
 3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
 4. Arc flash evaluations summary spreadsheet.

5. Bus detail sheets.
6. Arc flash warning labels printed in color on thermally bonded adhesive backed UV and weather-resistant labels.

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

- A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV- and weather-resistant labels. An example label is located following end of section in Figure 1.

PART 3 EXECUTION

3.01 GENERAL

- A. Adjust relay and protective device settings according to values established by coordination study.
- B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- C. Notify Engineer in writing of required major equipment modifications.
- D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.
- E. Provide arc flash warning labels on equipment as specified in this section.

3.02 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is a part of this Specification:
 1. Figure 1: Example Arc Flash Label.

END OF SECTION

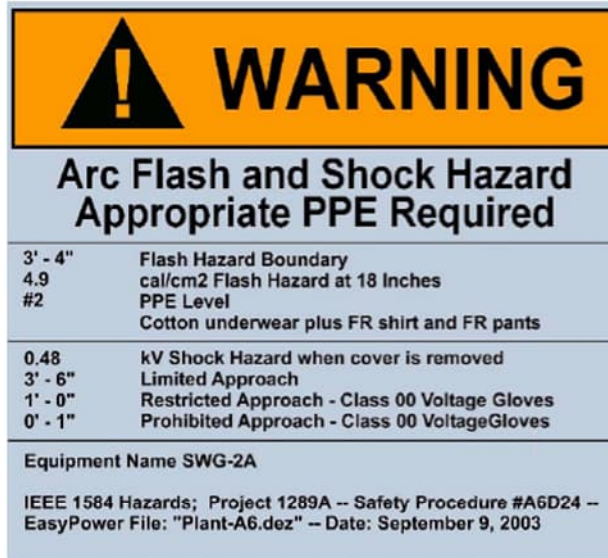


Figure 1
Example Arc Flash Label

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. D877/D877M, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - b. D923, Standard Practices for Sampling Electrical Insulating Liquids.
 - c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - f. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
 - j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43, Recommended Practice for Testing Insulation Resistance of Electric Machinery.
 - b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
 - c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
 - d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.

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- e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above.
 - g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 - h. C2, National Electrical Safety Code.
 - i. C37.20.1, Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear.
 - j. C37.20.2, Standard for Metal-Clad Switchgear.
 - k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
 - l. C37.23, Standard for Metal-Enclosed Bus.
 - m. C62.33, Standard Test Methods and Performance Values for Metal-Oxide Varistor Surge Protective Components.
3. Insulated Cable Engineers Association (ICEA):
 - a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
 - b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
 - c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
 4. National Electrical Manufacturers Association (NEMA):
 - a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
 - b. PB 2, Deadfront Distribution Switchboards.
 - c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
 5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70B, Recommended Practice for Electrical Equipment Maintenance.
 - c. 70E, Standard for Electrical Safety in the Workplace.
 - d. 101, Life Safety Code.
 7. National Institute for Certification in Engineering Technologies (NICET).
 8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.02 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. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
 - a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
 - b. Staged sequence of initial energization of electrical equipment.
 - c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
 - d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:
 - a. In accordance with Section 01 78 23, Operation and Maintenance Data.
 - b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.

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6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
 7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
 8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.
- B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.
- C. Test Instrument Calibration: In accordance with NETA ATS.

1.04 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.
1. Scheduled with Engineer prior to de-energization.
 2. Minimized to avoid extended period of interruption to the operating plant equipment.
- C. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing 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.

- C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.
- D. Set, test, and calibrate, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.
- E. Adjust mechanisms and moving parts of equipment for free mechanical movement.
- F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- 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 in NETA ATS.
- 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.

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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. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
2. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
 - a. Submit Voltage Field Test Report within 5 days of test.
3. Unbalance Corrections:
 - a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
 - b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 PANELBOARDS

A. This section only applies to the folwoings:

1. W. J. Hooper WPP; “PPH-UV2”.
2. Terry R. Hicks WPP, “PPF-UV2”.

- B. Visual and Mechanical Inspection: Include the following inspections and related work:
1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
 2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 3. Check panelboard mounting, area clearances, and alignment and fit of components.
 4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 5. Perform visual and mechanical inspection for overcurrent protective devices.
- C. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - b. Each phase of each bus section.
 - c. Phase-to-phase and phase-to-ground for 1 minute.
 - d. With switches and breakers open.
 - e. With switches and breakers closed.
 - f. Control wiring except that connected to solid state components.
 - g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 2. Ground continuity test ground bus to system ground.

3.04 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

- A. Visual and Mechanical Inspection:
1. Inspect each individual exposed power cable No. 6 and larger for:
 - a. Physical damage.
 - b. Proper connections in accordance with single-line diagram.
 - c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
 - d. Color coding conformance with specification.
 - e. Proper circuit identification.

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2. Mechanical Connections for:
 - a. Proper lug type for conductor material.
 - b. Proper lug installation.
 - c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 3. Shielded Instrumentation Cables for:
 - a. Proper shield grounding.
 - b. Proper terminations.
 - c. Proper circuit identification.
 4. Control Cables for:
 - a. Proper termination.
 - b. Proper circuit identification.
 5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.
- B. Electrical Tests for Conductors No. 6 and Larger:
1. Insulation Resistance Tests:
 - a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
 - b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
 - c. Evaluate ohmic values by comparison with conductors of same length and type.
 - d. Investigate values less than 50 megohms.
 2. Continuity test by ohmmeter method to ensure proper cable connections.
- C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.05 SAFETY SWITCHES, 600 VOLTS MAXIMUM

- A. Visual and Mechanical Inspection:
1. Proper blade pressure and alignment.
 2. Proper operation of switch operating handle.
 3. Adequate mechanical support for each fuse.
 4. Proper contact-to-contact tightness between fuse clip and fuse.
 5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
 6. Proper phase barrier material and installation.
 7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.

8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
 - c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each switch blade and fuse holder.
 - b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.06 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

- A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
 - b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.

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- c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - d. Test values to comply with NETA ATS, Table 100.1.
 2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each pole.
 - b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 3. Primary Current Injection Test to Verify:
 - a. Long-time minimum pickup and delay.
 - b. Short-time pickup and delay.
 - c. Ground fault pickup and delay.
 - d. Instantaneous pickup by run-up or pulse method.
 - e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
 - g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.07 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
 - a. Cracked insulation.
 - b. Broken leads or defective wiring.
 - c. Proper connections.
 - d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically:
 - a. Grounding and shorting connections have good contact.
 - b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
 - a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
 - b. Polarity test.
 - c. Ratio and accuracy test.

2. Potential Transformer Tests:
 - a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
 - c. Ratio and accuracy test.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.08 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

3.09 THERMOGRAPHIC SURVEY

- A. Provide thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 4 and larger at each:
 1. Panelboard.
- B. Provide thermographic survey of feeder conductors No. 4 and larger terminating at:
 1. Motors rated 50 hp and larger.
 2. Low voltage disconnect switches.
- C. Remove necessary enclosure metal panels and covers prior to performing survey.

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- D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.
- E. Do not perform survey on equipment operating at less than 40 percent of rated load. If plant load is insufficient, perform test with supplemental load bank producing rated load on item being measured.
- F. Use thermographic equipment capable of:
 - 1. Detecting emitted radiation.
 - 2. Converting detected radiation to visual signal.
 - 3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.
- G. Temperature Gradients:
 - 1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
 - 2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
 - 3. 16 degrees C and above indicates deficiency that is to be corrected immediately.
- H. Provide written report of:
 - 1. Areas surveyed and the resultant temperature gradients.
 - 2. Locations of areas having temperature gradients of 3 degrees C or greater.
 - 3. Cause of heat rise and actions taken to correct cause of heat rise.
 - 4. Detected phase unbalance.

END OF SECTION

SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
 2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
 3. ASTM International (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
 - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 4. International Code Council (ICC):
 5. International Building Code (IBC).
 6. International Mechanical Code (IMC).
 7. Manufacturers' Standardization Society (MSS):
 - a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
 - b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

- A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

- A. Action Submittals:
1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for all piping. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.

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2. Calculations for each type of pipe support, attachment and anchor.
3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Maintenance information on piping support system.

1.04 QUALIFICATIONS

- A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer in the state where the Work is to be installed.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. All Pipe Sizes: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.
 - a. Ductile-iron Pipe 8 Inches and Under: Maximum span limited to that for standard weight steel pipe for water service.
 - b. Ductile-iron Pipe 10 Inches and Larger: Maximum span limited to 20 feet.
3. Electrical Conduit Support: Include in design of framing support system.

- C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.
- D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

PART 2 PRODUCTS

2.01 MATERIALS OF CONSTRUCTION

- A. Stainless Steel unless otherwise noted in the Drawings.

2.02 GENERAL

- A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.
- B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.
- C. Materials: In accordance with Table 1, attached as Supplement at end of section.

2.03 HANGERS

- A. Clevis: MSS SP 58, Type 1:
 - 1. Anvil; Figure 260 for steel pipe and Figure 590 for ductile-iron pipe, sizes 1/2 inch through 30 inches.
 - 2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 16 inches.
 - 3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.
- B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6:
 - 1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
 - 2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.
- C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43:
 - 1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1 inch through 30 inches.
 - 2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

D. Pipe Rollers and Supports: MSS SP 58, Type 44:

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.04 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable “J” hanger MSS SP 58, Type 5:

1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.

C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4 inch through 8 inches.

D. Channel Type:

1. Unistrut.
2. Anvil; Power-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).

2.05 PIPE SADDLES

A. Concrete supports as indicated in the Drawings.

2.06 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer’s allowable loads.

C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.

4. Aickinstrut (FRP System).
5. Enduro-Durostrut (FRP Systems).
6. “Or-Equal.”

2.07 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, Type 8:

1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.08 ELBOW AND FLANGE SUPPORTS

- A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.
- B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.
- C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.09 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product:
 - a. B-Line; Figure B3552, 1-1/2 inches through 30 inches.
 - b. “Or-Equal.”

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.10 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.
3. “Or-Equal.”

2.11 PIPE ANCHORS

- A. Type: Anchor chair with U-bolt strap.
- B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.12 ACCESSORIES

- A. Anchor Bolts:
 - 1. Size and Material: Sized by Contractor for required loads, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
 - 2. Bolt Length (Extension Above Top of Nut):
 - a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
 - b. Maximum Length: No more than a full nut depth above top of nut.
- B. Dielectric Barriers:
 - 1. Plastic coated hangers, isolation cushion, or tape.
 - 2. Manufacturer and Products:
 - a. B-Line; B1999 Vibra Cushion.
 - b. B-Line; Iso Pipe, Isolation Tape.
 - c. "Or-Equal."
- C. Insulation Shields:
 - 1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
 - b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.
 - c. "Or-Equal."
- D. Welding Insulation Saddles:
 - 1. Type: MSS SP 58, Type 39.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
 - b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.
 - c. "Or-Equal."
- E. Plastic Pipe Support Channel:
 - 1. Type: Continuous support for plastic pipe and to increase support spacing.

2. Manufacturer and Product:
 - a. B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.
 - b. “Or-Equal.”
- F. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.
- G. Attachments:
 1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
 2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
 3. Welded Beam Attachment: MSS SP 58, Type 22.
 - a. Anvil; Figure 66.
 - b. B-Line; Figure B3083.
 4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
 5. Concrete Attachment Plates:
 - a. Anvil; Figure 47, Figure 49, or Figure 52.
 - b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
 2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
 3. Support piping connections to equipment by pipe support and not by equipment.
 4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
 5. Support no pipe from pipe above it.
 6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
 7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
 8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.

9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
 - a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
 - b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
 - a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
 - b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
 - c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
 - a. Saddle Supports:
 - 1) Pedestal Type, elbow and flange.
 - 2) Provide minimum 1-1/2-inch grout beneath baseplate.
 - b. Floor Mounted Channel Supports:
 - 1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
 - 2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
 - 3) Attach pipe to channel with clips or pipe clamps.
 - c. Concrete Cradles: Use for pipe as indicated on the Drawings.
4. Insulated Pipe:
 - a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.
 - b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
 - c. Wall-mounted pipe clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments.

D. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

E. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
3. Dielectric Barrier:
 - a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
 - b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this Specification:

1. Table 1: Chemical Areas.

END OF SECTION

Table 1 Chemical Areas		
Exposure Conditions	Support for Direct Exposure	Support for Remote Exposure
Alum	FRP	Precoated steel
Aqua Ammonia	Stainless steel	Precoated steel
Coagulants	FRP	Precoated steel or galvanized steel
Ferric Chloride	FRP	Precoated steel
Ferric Sulfate	FRP	Precoated steel
Hydrofluorosilic Acid	FRP	Precoated steel
Lime	Stainless steel, FRP, precoated steel	Stainless steel, FRP, precoated steel
Methanol	Galvanized steel	Galvanized steel
Polymers	FRP	Precoated steel
Potassium Permanganate	Precoated steel	Precoated steel
Powdered Activated Carbon	Precoated steel	Precoated steel
Sodium Carbonate	Stainless steel	Precoated steel
Sodium Hydroxide	Stainless steel	Precoated steel
Sodium Hypochlorite	FRP	Precoated steel
Sulfuric Acid	Stainless steel	Precoated steel
<p>Notes:</p> <ol style="list-style-type: none"> 1. Direct exposure includes entire area within containment area; area within 20 feet horizontal and 10 feet vertical of chemical pumps or chemical mixing stations; or as specified. 2. Remote exposure is area beyond area defined as direct exposure, but within designated building. 3. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol). 4. Stainless steel to be Type 304. 5. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M. 6. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces. 		

SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:
1. American Society of Mechanical Engineers (ASME):
 - a. B1.20.1, Pipe Threads, General Purpose (Inch).
 - b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250.
 - c. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
 - d. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
 - e. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
 - f. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
 2. American Water Works Association (AWWA): C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 3. ASTM International (ASTM):
 - a. A536, Standard Specification for Ductile Iron Castings.
 - b. D1330, Standard Specification for Rubber Sheet Gaskets.
 4. NSF International (NSF):
 - a. ANSI 61: Drinking Water System Components - Health Effects.
 - b. ANSI 372: Drinking Water System Components - Lead Content.
 5. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
 6. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 7. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 8. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 9. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 10. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 11. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.

12. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
 - a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
 - b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Corrosion Protection: Product data.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
 - a. Pipe and fittings.
 - b. Factory applied resins and coatings.
2. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torquing requirements and bolt tightening procedures.
3. Test logs.
4. Pipe coating applicator certification.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.

4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 GENERAL

- A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

- A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement and on Piping Schedule located on the Drawings.
- B. Diameters Shown:
 1. Standardized Products: Nominal size.

2.03 JOINTS

- A. Flanged Joints:
 1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
 2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.
- B. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

2.04 GASKET LUBRICANT

- A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.05 PIPE CORROSION PROTECTION

- A. Coatings: See Pipe Schedule, for details of coating requirements.

2.06 FABRICATION

- A. Mark each pipe length on outside with the following:
 - 1. Size or diameter and class.
 - 2. Manufacturer's identification and pipe serial number.
 - 3. Location number on laying drawing.
 - 4. Date of manufacture.
- B. Code markings according to approved Shop Drawings.
- C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.07 FINISHES

- A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.
- B. Galvanizing:
 - 1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
 - 2. Electroplated zinc or cadmium plating is unacceptable.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.
- B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

- A. Prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.
- B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

- C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.
- D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions, except for damaged glass-lined pipe or PVDF-lined pipe that is to be promptly removed from Site.

3.03 INSTALLATION—GENERAL

- A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
- B. Remove foreign objects prior to assembly and installation.
- C. Flanged Joints:
 - 1. Install perpendicular to pipe centerline.
 - 2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
 - 3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
 - 4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
 - 5. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
 - 6. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
 - 7. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
 - 8. Manufacturer: Same as pipe manufacturer.
- D. Threaded and Coupled Joints:
 - 1. Conform to ASME B1.20.1.
 - 2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
 - 3. Countersink pipe ends, ream and clean chips and burrs after threading.
 - 4. Make connections with not more than three threads exposed.
 - 5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.
- E. PVC and CPVC Piping:
 - 1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.

2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

F. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
 - a. General: As required for the type of joint to be made.
 - b. Rubber Gasketed Joints: Remove sharp edges or projections.
 - c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
 - d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

3.04 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1 inch(es) from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.05 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.

3.06 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.07 FIELD FINISHING

- A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.
- B. As specified in Section 09 90 00, Painting and Coating.

3.08 PIPE IDENTIFICATION

- A. As specified in Section 10 14 00, Signage.

3.09 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: Perform in-service testing in lieu of pressure leakage testing. Prior to testing the UV system, perform in-service testing and monitor for visible leaks. Stop test if leakage is observed during testing. Address the leak and restart testing.

3.10 CLEANING

- A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.
- B. Blow clean of loose debris and instrument air lines with compressed air at 4,000 fpm; do not flush with water.
- C. Immediately after cleaning service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.
- D. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.
- E. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.
- F. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.11 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Pipe Schedule Legend.
2. Piping Schedule.
3. Data Sheets.

Number	Title
40 27 00.01	Cement-Mortar Lined Ductile Iron Pipe and Fittings
40 27 00.07	Galvanized Steel Pipe and Malleable Iron Fittings
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings

END OF SECTION

PIPING SCHEDULE LEGEND

SERVICE

CL/LI	Chlorine/Lime
DR	Drain
FW	Finished Water
FLW	Filtered Water
SA	Sample

EXPOSURE

EXP	Exposed
-----	---------

MATERIAL

CLDI	Cement-Lined Ductile Iron
PVC	Polyvinyl Chloride
GSp	Galvanized Steel Pipe

JOINT TYPE

FL	Flanged
TH	Threaded

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Piping Schedule									
Service	Size(s) (In.) ¹	Exposure	Piping Material	Specification Section	Joint Type	Lining/ Coating ²	Test Pressure (psig-x), x = Type indicated in Legend	Pipe Color	Remarks
CL/LI	2	EXP	GSP		TH	No Lining/System 10 Paint		No color	
FLW	36-42	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
UVI	36	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
UVE	36	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
FW	20- 42-	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
DR	2	EXP	PVC		TH		-	No Color	
SA	1-1/2	EXP	GSP		TH		9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	No color	

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Piping Schedule									
Service	Size(s) (In.) ¹	Exposure	Piping Material	Specification Section	Joint Type	Lining/ Coating ²	Test Pressure (psig-x), x = Type indicated in Legend	Pipe Color	Remarks
CL/LI	2	EXP	GSP		TH	No Lining/System 10 Paint		No color	
FLW	36-42	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
UVI	36	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
UVE	36	EXP	CLDI	40 27 00.01	FL	Cement Mortar Lined/System 4 Paint	9 psi for Hicks WPP, in-service 16 psi for Hooper WPP, in-service	Match existing	
<p>¹“>” Greater Than “<” Less Than “<=” Less Than or Equal To “>=” Greater Than or Equal To “All” All Sizes</p> <p>²Coating system number as specified in Section 09 90 00, Painting and Coating, and as specified in Article Pipe Corrosion Protection.</p>									

SECTION 40 27 00.01 CEMENT-MORTAR LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
General	<p>Materials in contact with potable water shall conform to NSF 61 acceptance.</p> <p>Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA C151/A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).</p>
Pipe	Exposed Pipe Using Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4.
Fittings	<p>Lined and coated same as pipe.</p> <p>Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.</p>
Joints	<p>Mechanical: 250 psi minimum working pressure.</p> <p>Flange: Dimensions per AWWA C110/A21.10 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed.</p>
Bolting	Flanged: ASTM A307, Grade B carbon steel heavy hex head or stud bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations.
Gaskets	<p>General: Gaskets in contact with potable water shall be NSF ANSI 61 certified.</p> <p>Flanged, Water, Sewage and Hot Air Services: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000.</p>

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SECTION 40 27 00.01 CEMENT-MORTAR LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
	Full face for flat-faced flanges, flat-ring type for raised-face flanges. Blind flanges shall be epoxy-lined in accordance with the system specified above. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

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SECTION 40 27 00.07 GALVANIZED STEEL PIPE AND MALLEABLE IRON FITTINGS		
Item	Size	Description
Pipe	1-1/2" & smaller 2" thru 6" 8" thru 12" 14"	Galvanized carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53, Grade B seamless or ERW. Standard weight. Standard weight. Standard weight. Standard weight.
Joints	1-1/2" & smaller 2" & larger	Threaded or flanged at valves and equipment, or grooved end meeting requirements of AWWA C606. Flanged at valves and equipment, or grooved end meeting requirements of AWWA C606.
Fittings	1-1/2" & smaller 2" & larger	Threaded: 150-pound or 300-pound malleable iron, ASTM A197A197M or ASTM A47/A47M, dimensions in accordance with ASME B16.3. Grooved End: Malleable iron ASTM A47/A47M or ductile iron ASTM A536, 250 psi working pressure, grooved ends to accept couplings without field preparation. Victaulic; Anvil International, Inc., Gruvlok.
Branch Connections	1-1/2" & smaller 2" & larger	Tee or reducing tee in conformance with Fittings above, galvanized 2,000-pound WOG threadolet or welding boss; galvanize after welding. Branch Same Size as Run: Grooved end tee in accordance with Fittings above. Branch One or More Sizes Smaller Than Run: Grooved end reducing tee in accordance with Fittings above.
Flanges	1-1/2" & smaller	Galvanized, forged carbon steel, ASTM A105/A105M, Grade II, ASME B16.5 Class 150 or Class 300, socket-weld or threaded, 1/16-inch raised face.

SECTION 40 27 00.07		
GALVANIZED STEEL PIPE AND MALLEABLE IRON FITTINGS		
Item	Size	Description
	2" & larger	<p>Butt-Welded Systems Standard Flange (RFWN): Galvanized, forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/8-inch raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside.</p> <p>Butt-Welded Systems Standard Flange (FFWN): Galvanized, forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/8-inch flat face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside.</p> <p>Butt-Welded Systems Blind Flange: Galvanized, forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150, 1/8-inch flat face.</p> <p>Grooved End Adapter Flange: Malleable iron ASTM A47/A47M or ductile iron ASTM A536. Victaulic Style 741 or 743; Anvil International, Inc., Gruvlok Figure 7012 or 7013; Shurjoint Model 7041-A. Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.</p>
Unions		Threaded malleable iron, ASTM A197/A197M or ASTM A47/A47M, 300-pound WOG, brass to iron seat, meeting the requirements of ASME B16.3.
Couplings		Grooved End: Rigid joint malleable iron, ASTM A47/A47M or ductile iron, ASTM A536, 250 psi working pressure. Victaulic; Anvil International, Inc., Gruvlok.
Plugs		Forged carbon steel, ASTM A181/A181M, Grade II, round head, threaded, galvanized.

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	Size	Description
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
 - b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
 2. American Water Works Association (AWWA):
 - a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
 - b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
 - c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
 - d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
 - e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
 - f. Manual M11, Steel Pipe—A Guide for Design and Installation.
 3. ASTM International (ASTM):
 - a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes.
 4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
 5. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

- A. Action Submittals:
1. Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
 2. Chemical Injectors:
 - a. Type, size, quantity, materials, and model number of each.
 - b. Sketch of each showing major parts, main pipe, and dimensions.

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- c. Details and model number of each support system and component.
 - d. Details and model of connects (for example, service saddle, weld-o-let).
- B. Informational Submittals:
- 1. Coupling Harness:
 - a. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
 - b. Weld procedure qualifications.
 - c. Load proof-testing report of prototype restraint for any size coupling.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on the Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.
- C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 COUPLINGS

- A. General:
 - 1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
 - 2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
 - 3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.

4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on the Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Restrained Flange Adapter:

1. Pressure Rating:
 - a. Minimum Working Pressure Rating: Not less than 150 psi.
 - b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
 - a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
 - b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product:
 - a. EBAA Iron Sales Co.; Mega-Flange.
 - b. "Or-Equal."

2.03 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
 - a. Body: Malleable or ductile iron.
 - b. Straps: Galvanized steel.
 - c. Hex Nuts and Washers: Steel.
 - d. Seal: Rubber.
5. Manufacturers and Products:
 - a. Smith-Blair; Series 366.
 - b. Cascade Waterworks Mfg. CFT-TO.
 - c. "Or-Equal."

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2.04 EXPANSION JOINTS

A. Elastomer Bellows:

1. Type: Reinforced molded wide arch.
2. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with split galvanized steel retaining rings.
3. Washers: Over retaining rings to help provide leak-proof joint under test pressure.
4. Thrust Protection: Control rods to protect the bellows from overextension.
5. Bellows Arch Lining: Buna-N, nitrile, or butyl.
6. Rated Temperature: 250 degrees F.
7. Rated Deflection and Pressure:
 - a. Lateral Deflection: 0.9 inch, minimum.
 - b. Burst Pressure: Four times the working pressure.
 - c. Axial Compression: 2 inch, Axial Extension – 1 inch.
8. Manufacturers and Products:
 - a. General Rubber Corp.; Style 1101.
 - b. Mercer; Flexmore Style 450.
 - c. Goodall Rubber Co.; Specification E-711.
 - d. Unisource Manufacturing, Inc.; Series 1500.
 - e. Proco Products, Inc.; Style 231.
 - f. “Or-Equal.”

2.05 CHEMICAL INJECTOR SYSTEM

A. Chemical Injectors:

1. Type, size, quantity, and materials as shown on the Drawings and Standard Details.
2. Manufacturer:
 - a. SAF-T-FLO.
 - b. “Or-Equal.”

B. Support System:

1. Stainless steel Unistrut or FRP Aickenstrut.
2. Materials compatible with chemical service and subject to Engineer approval.

C. Connectors: Stainless steel service saddle or weld-o-let, as shown on the Drawings.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING EXPANSION

- A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.
- B. Expansion Joints:
 - 1. Flanged Piping Systems: Elastomer bellows expansion joint.

3.03 COUPLINGS

- A. General:
 - 1. Install in accordance with manufacturer's written instructions.
 - 2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
 - 3. Do not remove pipe coating. If damaged, repair before joint is made.
 - 4. Application:
 - a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.

3.04 CHEMICAL INJECTOR SYSTEM

- A. Install in accordance with manufacturer's instructions.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 2. American Water Works Association (AWWA):
 - a. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
 - b. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
 3. ASTM International (ASTM): D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 4. FM Global (FM).
 5. International Association of Plumbing and Mechanical Officials (IAPMO).
 6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 7. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
 8. UL.

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
 - b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Certification for compliance to NSF/ANSI 61 for valves used for drinking water service.

- d. Power and control wiring diagrams, including terminals and numbers.
 - e. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
 - f. Sizing calculations for open-close/throttle and modulating valves.
- B. Informational Submittals:
- 1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
 - a. Electric actuators; full compliance with AWWA C542.
 - b. Butterfly valves; full compliance with AWWA C504.
 - 2. Tests and inspection data.
 - 3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL

- A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.
- B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.
- C. Valve same size as adjoining pipe, unless otherwise called out on the Drawings or in Supplements.
- D. Valve ends to suit adjacent piping.
- E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.
- F. Size operators and actuators to operate valve for full range of pressures and velocities.
- G. Valve to open by turning counterclockwise, unless otherwise specified.
- H. Factory mount operator, actuator, and accessories.

- I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

- A. Additional requirements relative to this section are shown on Electric Actuated Valve Schedule and Self-Regulated Valve Schedule located at the end of this section.

2.03 MATERIALS

- A. Valve materials in contact with or intended for drinking water service to meet the following requirements:
 - 1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
 - 2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.
 - 3. Supply certification product is certified as suitable for contact with drinking water by an accredited certification organization in accordance with NSF/ANSI 61. Provide certification for each valve type used for drinking water service.

2.04 FACTORY FINISHING

- A. General:
 - 1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
 - 2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
 - 3. Material in contact with potable water shall conform to NSF/ANSI 61.
 - 4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

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- B. Where epoxy lining and coating are specified, factory finishing shall be as follows:
1. In accordance with AWWA C550.
 2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
 3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
 - a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
 - b. Manufacturers and Products:
 - 1) Threaded:
 - a) Conbraco Apollo; 70-100.
 - b) Nibco; T-580-70.
 - c) “Or-Equal.”
1. Type V330 PVC Ball Valve 2 Inches and Smaller:
 - a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions.
 - b. Manufacturers and Products:
 - 1) Nibco; Chemtrol Tru-Bloc.
 - 2) ASAHI/America; Type 21.
 - 3) Spears; True Union.

B. Plug Valves:

1. Type V400 Eccentric Plug Valve 2 Inches and Smaller:
 - a. Nonlubricated type rated 175 psig CWP, drip tight shutoff with pressure from either direction, cast-iron body, threaded ends, lever operator, cast-iron plug with round or rectangular port, plug coated with Buna-N, stem bearing lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber.

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- b. Manufacturers and Products:
 - 1) Pratt; Ballcentric.
 - 2) DeZurik; Style PEC.
 - 3) Milliken; Millcentric Series 603.
 - 4) “Or-Equal.”
- c. Valves to be in full compliance with NSF/ANSI 61. Provide NSF/ANSI 61 certificate for each valve.

C. Butterfly Valves:

- 1. General:
 - a. In full compliance with AWWA C504 and following requirements:
 - 1) Suitable for throttling operations and infrequent operation after periods of inactivity.
 - 2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
 - 3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
 - 4) No travel stops for disc on interior of body.
 - 5) Self-adjusting V-type or O-ring shaft seals.
 - 6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
 - 7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
 - 8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
 - 9) Provide linings and coatings per AWWA, unless otherwise indicated on the Drawings or specified herein.
 - 10) Valves to be in full compliance with NSF/ANSI 61. Provide NSF/ANSI 61 certificate for each valve.
 - b. Non-AWWA butterfly valves to meet the following actuator requirements: For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on the Drawings or specified herein.
- 2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
 - a. AWWA C504, Class 150B.
 - b. Short body type, flanged ends.

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- c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, EPDM rubber seat bonded or molded in body only, and stainless steel seating surface.
- d. Provide epoxy lining in compliance with AWWA C550.
- e. Manufacturers and Products:
 - 1) Pratt; Model 2FII or Triton XR-70.
 - 2) DeZurik; AWWA Valve.
 - 3) “Or-Equal.”

D. Self-Regulated Automatic Valves:

- 1. Type V740 Air Release Valve 1/2 Inch to 16 Inches:
 - a. 1/2-inch through 3-inch NPT inlets and outlets, 4-inch and larger ASME B16.1 Class 125 flanged inlet with plain outlet and protective hood.
 - b. Rated 150psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.
 - c. Rated for working pressure less than 5 psi for Hicks WPP.
 - d. Manufacturers and Products:
 - 1) APCO Valve and Primer Corp.; Series 140 or 150.
 - 2) Val-Matic Valve; Series 100.
 - 3) “Or-Equal.”

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

- 1. General:
 - a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
 - b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
 - c. Operator self-locking type or equipped with self-locking device.
 - d. Position indicator on quarter-turn valves.
 - e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator’s threaded steel reach rod with internally threaded bronze or ductile iron nut.

2. Exposed Operator:
 - a. Galvanized and painted handwheel.
 - b. Cranks on gear type operator.
 - c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
 - d. Valve handles to take a padlock, and wheels a chain and padlock.

- B. Electric Motor Actuators, 480 Volts:
 1. General:
 - a. Comply with latest version of AWWA C542.
 - b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
 - c. Controls integral with actuator and fully equipped as specified in AWWA C542.
 - d. Stem protection for rising stem valves.
 2. Actuator Operation—General:
 - a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
 - b. Manual override handwheel.
 - c. Valve position indication.
 - d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.
 - e. Nonintrusive Electronic Control: Local controls, diagnostics, and calibration, including limit and torque settings, shall be accomplished nonintrusively. Electronic valve position display with capability to show continuous torque output. If applicable, provide two hand-held configuration units for every 10 actuators provided, two minimum.
 3. Open-Close(O/C)/Throttling(T) Service:
 - a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.
 - b. Actuator suitable for throttling operation of valve at intermediate positions.
 - c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
 - 1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
 - 2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.
 - 3) Auxiliary contact that closes in REMOTE position.

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- d. OPEN and CLOSED indicating lights.
- e. Integral reversing motor starter with built-in overload protection.
- 4. Modulating (M) Service:
 - a. Size actuators for continuous modulating duty.
 - b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
 - c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
 - 1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
 - 2) 4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.
 - 3) Auxiliary contact that closes in AUTO (Remote) position.
 - d. OPEN and CLOSED indicating lights.
 - e. Ac motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
 - f. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.
 - g. Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.
- 5. Limit Switch:
 - a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
 - b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
 - c. Housed in actuator control enclosure.
- 6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
- 7. Manufacturers and Products:
 - a. Rotork Controls; IQ20.
 - b. Flowserve Limitorque;MX-WG.
 - c. “Or-Equal.”

2.07 ACCESSORIES

- A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve, bearing valve tag number shown on Electric Actuated Valve Schedule, Self-Regulated Valve Schedule and/or the Drawings.

B. Limit Switch:

1. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
2. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
3. Housed in actuator control enclosure.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Threaded Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
 - a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
 - b. Install valves in location for easy access for routine operation and maintenance.
 - c. Install valves per manufacturer's recommendations.
2. Ball Valves:
 - a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
 - b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
 - a. Unless otherwise restricted or shown on the Drawings, install valve as follows:
 - 1) Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).

4. Butterfly Valves:
 - a. Unless otherwise restricted or shown on the Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
 - b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
 - c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
 - d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
 - e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
- E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.
- F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

3.02 TESTS AND INSPECTION

- A. Valve may be either tested while testing pipelines, or as a separate step.
- B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.
- C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.
- D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.
- E. Set, verify, and record set pressures for relief and regulating valves.
- F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.
- G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are part of this Specification.
1. Electric Actuated Valve Schedule.
 2. Self-Regulated Valve Schedule.

END OF SECTION

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Electric Actuated Valve Schedule									
WPP	Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Process Fluid	Maximum Operating Flow (mgd)	Maximum ΔP (psi)	Service	Control Feature Modifications/Supplements
Hicks WPP	305-FV1A 305FV1B	V-500	480 volt, three-phase	36	UVI	3.9-10.0	9 psi	Open/Close	Controlled from the SCC
Hicks WPP	305-FCV2A 305-FCV2B	V-500	480 volt, three-phase	36	UVE	3.9-10.0	9 psi	Modulating	Controlled from the SCC
Hooper WPP	305-FV1A 305FV1B	V-500	480 volt, three-phase	36	UVI	11.6-22.0	16 psi	Open/Close	Controlled from the SCC
Hooper WPP	305-FCV2A 305-FCV2B	V-500	480 volt, three-phase	36	UVE	11.6-22.0	16 psi	Modulating	Controlled from the SCC
Hicks WPP	306-FCV	V-500	480 volt, three-phase	30	UVE	3.9-10.0	9 psi	Modulating	Controlled from Plant PLC

Service: O/C = Open-Close, T = Throttling, M = Modulating
Control Feature Modifications/Supplements:
A = Actuator shall open valve upon loss of signal.
B = Actuator shall close valve upon loss of signal.
C = Actuator shall remain in last position upon loss of signal.
D = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.
E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.
F = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.
G = Motor and control enclosure(s) NEMA 250, Type 4 with 120-volt space heaters.
H = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) with 120-volt space heaters.
I = Motor and control enclosure(s) NEMA 250, Type 7 with 120-volt space heaters.
J = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.
K = 120-volt secondary control power transformer.
L = Externally operable power disconnect switch.

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Self-Regulated Valve Schedule							
Tag No.	Valve Type No.	Size (inches)	Inlet* Pressure	Outlet* Pressure	Minimum (psig)	Maximum (psig)	Fluid
305ARV1A (Hicks WPP)	V740	1-1/2	NA	NA	4	9	Filtered Water
305ARV1A (Hooper WPP)	V740	1-1/2	NA	NA	14	16	Filtered Water
305ARV2A (Hicks WPP)	V740	1-1/2	NA	NA	4	9	UV Influent Water
305ARV2A (Hooper WPP)	V740	1-1/2	NA	NA	14	16	UV Influent Water
305ARV2B (Hicks WPP)	V740	1-1/2	NA	NA	4	9	UV Influent Water
305ARV2B (Hooper WPP)	V740	1-1/2	NA	NA	14	16	UV Influent Water
*Inlet Pressure = Set pressure for pressure relief valve or downstream set pressure for pressure reducing valve.							

SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - b. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
 - c. A312, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
 - d. B32, Standard Specification for Solder Metal.
 - e. B88, Standard Specification for Seamless Copper Water Tube.
 2. International Society of Automation (ISA):
 - a. S5.1, Instrumentation Symbols and Identification (NRC ADOPTED).
 - b. PR12.6, Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.
 - c. S5.4, Standard Instrument Loop Diagrams.
 - d. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
 - e. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. ICS 1, General Standards for Industrial Control and Systems.
 4. National Institute of Standards and Technology (NIST).
 5. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
 6. UL: 508A, Standard for Safety, Industrial Control Panels.

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1.02 SUMMARY

A. Work Includes:

1. Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for complete Process Instrumentation and Control (PIC) for plant.
2. Major parts are:
 - a. Primary elements, transmitters, control devices and control panels.
 - b. Integration of vendor (Trojan) provided PLC based UV systems.
 - 1) Hooper WPP: Provide new Fiber Optic cable between new UV system and existing Transfer Pump Station Panel in the High Service Building.
 - 2) Hicks WPP: Provide new Fiber Optic cable between new UV system and existing CP-A in the Admin Building.
 - c. Integration of new systems and controls into existing iFIX HMI system. Create displays as required for the process equipment as depicted on the Contract Drawings. Modify existing graphics as required. Contractor shall follow the existing graphics standards to provide consistent look and feel.
 - d. Application software shall be provided by the Contractor. Work includes but is not limited to, programming of the new PLC provided under this section or of other PICS subsystem sections, modifications to the existing PLC(s) as required, configuration of the existing servers and PLC networks and additions/modifications to the Wonderware application software.

B. Detailed Design: PIC as shown and specified includes functional and performance requirements and component specifications. Complete detailed PIC design.

C. PIC System Integrator has been pre-selected by the Owner: MR Systems, Norcross, GA.

1.03 DEFINITIONS

A. Abbreviations:

1. CP: Control Panel.
2. FOFP: Fiber Optic Patch Panel.
3. FP: Field Panel.
4. HMI: Human Machine Interface.
5. LCP: Local Control Panel.
6. MCC: Motor Control Center.
7. PAT: Performance Acceptance Test.

8. PICS: Process Instrumentation and Control System.
 9. PLC: Programmable Logic Controller.
 10. PMCS: Process Management Control System.
 11. RIO: Remote Input/Output.
- B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.
1. Rising: Contacts close when an increasing process variable rises through setpoint.
 2. Falling: Contacts close when a decreasing process variable falls through setpoint.
- C. Signal Types:
1. Analog Signals, Current Type:
 - a. 4 mA to 20 mA dc signals conforming to ISA S50.1.
 - b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
 - 1) Transmitter Type: Number 2, two-wire.
 - 2) Transmitter Load Resistance Capacity: Class L.
 - 3) Fully isolated transmitters and receivers.
 2. Analog Signals, Voltage Type: 1 to 5 volts dc within panels where a common high precision dropping resistor is used.
 3. Discrete signals, two-state logic signals using 24V dc or 120V ac sources as indicated.
 4. Pulse Frequency Signals:
 - a. Direct current pulses whose repetition rate is linearly proportional to process variable.
 - b. Pulses generated by contact closures or solid-state switches as indicated.
 - c. Power source less than 30V dc.
 5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.
- D. Instrument Tag Numbers:
1. A shorthand tag number notation is used in the Loop Specifications. For example: 102AIT1-2(2)(3)[pH].

<u>Notation</u>	<u>Explanation</u>
10	Unit process number
2	Loop number

<u>Notation</u>	<u>Explanation</u>
AIT	ISA designator for Analysis Indicating Transmitter
(3)	First unit number; number of same 102-1 component types in a given loop; -1 and -2 in this example
2.	In this example, 102AIT-(3) is shorthand for: 102AIT1; 102AIT2; 102AIT3.

1.04 SUBMITTALS

A. Action Submittals:

1. General:
 - a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.
 - b. Identify proposed items and options. Identify installed spares and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
 - c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).
2. Bill of Materials: List of required equipment.
 - a. Group equipment items as follows:
 - 1) I&C Components: By component identification code.
 - 2) Other Equipment: By equipment type.
 - b. Data Included:
 - 1) Equipment tag number.
 - 2) Description.
 - 3) Manufacturer, complete model number, and all options not defined by model number.
 - 4) Quantity supplied.
 - 5) Component identification code where applicable.
3. Catalog Cuts: I&C Components, Electrical Devices, and Mechanical Devices:
 - a. Catalog information, mark to identify proposed items and options.
 - b. Descriptive literature.
 - c. External power and signal connections.
 - d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
4. Component Data Sheets: Data sheets for I&C components.
 - a. Format and Level of Detail: In accordance with ISA-S20.
 - b. Include component type identification code and tag number on data sheet.

- c. Specific features and configuration data for each component:
 - 1) Location or service.
 - 2) Manufacturer and complete model number.
 - 3) Size and scale range.
 - 4) Setpoints.
 - 5) Materials of construction.
 - 6) Options included.
- d. Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
5. Sizing and Selection Calculations:
 - a. Primary Elements: Complete calculations plus process data used. Example, for flow elements, minimum and maximum values, permanent head loss, and assumptions made.
 - b. Controlling, Computing and Function Generating Modules: Actual scaling factors with units and how they were computed.
6. Panel Construction Drawings:
 - a. Scale Drawings: Show dimensions and location of panel mounted devices, doors, louvers, and subpanels, internal and external.
 - b. Panel Legend: List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
 - c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
 - d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
 - e. Construction Notes: Finishes, wire color schemes, wire ratings, wire and terminal block, numbering and labeling scheme.
7. Panel Control Diagrams: For discrete control and power circuits.
 - a. Diagram Type: Ladder diagrams. Include devices, related to discrete functions, that are mounted in or on the panel and that require electrical connections. Show unique rung numbers on left side of each rung.
 - b. Item Identification: Identify each item with attributes listed.
 - 1) Wires: Wire number and color. Cable number if part of multiconductor cable.
 - 2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
 - 3) Discrete Components:
 - a) Tag number, terminal numbers, and location ("FIELD", enclosure number, or MCC number).

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- b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
- 4) Relay Coils:
 - a) Tag number and its function.
 - b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
- 5) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
- c. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be permitted.
- d. Ground wires, surge protectors, and connections.
- e. Circuit Names: Show names corresponding to Circuit and Raceway Schedule for circuits entering and leaving a panel. Refer to Division 26, Electrical.
- 8. Panel Wiring Diagrams: Show point-to-point and terminal-to-terminal wiring within panel.
- 9. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for: Pipes and Tubes: Thickness, pressure rating, and materials.
 - a. Components: Valves, regulators, and filters.
 - b. Connections to panel mounted devices.
 - c. Panel interface connections.
- 10. Loop Diagrams: Individual wiring diagram for each analog or pulse frequency loop.
 - a. Conform to the minimum requirements of ISA S5.4.
 - b. Under Paragraph 5.3 of ISA S5.4, include the information listed under subparagraphs 2 and 6.
 - c. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.
 - d. Divide each loop diagram into areas for panel face, back-of-panel, and field.
 - e. Show:
 - 1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
 - 2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
 - 3) Tabular summary on each diagram:
 - a) Transmitting Instruments: Output capability.
 - b) Receiving Instruments: Input impedance.

- c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
 - d) Total loop impedance.
 - e) Reserve output capacity.
 - 4) Circuit and raceway schedule names.
- 11. Interconnecting Wiring Diagrams:
 - a. Diagrams, device designations, and symbols in accordance with NEMA ICS 1.
 - b. Diagrams shall bear electrical Subcontractor's signature attesting diagrams have been coordinated with Division 26, Electrical.
 - c. Show:
 - 1) Electrical connections between equipment, consoles, panels, terminal junction boxes, and field mounted components.
 - 2) Component and panel terminal board identification numbers, and external wire and cable numbers.
 - 3) Circuit names matching Circuit and Raceway Schedule.
 - 4) Intermediate terminations between field elements and panels (for example, to terminal junction boxes and pull boxes).
 - 5) Pull boxes.
- 12. Fiber Optic Cable Site Layout Diagrams Showing:
 - a. Access holes, with identification.
 - b. Abovegrade cable routings, with pole and cable identification.
 - c. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.
 - d. Belowgrade innerduct routings through conduits, with innerduct counts and identification.
 - e. Cable routings through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identification.
- 13. Fiber Cable Schedule Showing:
 - a. Cable identification.
 - b. Fiber counts for each cable and identification of used fiber pairs.
 - c. Cable length and attenuation, with connector pairs and patch cords, based on TIA 568-C.3, Annex H. Calculations to show the following:
 - 1) Light emitter/receiver power budget in dB.
 - 2) Attenuation due to cable for each path.
 - 3) Attenuation due to connector loss.
 - 4) Attenuation due to patch cable loss.
 - 5) Reserve light budget required for each device.
 - 6) Total attenuation for each path.
 - 7) Total remaining light budget for each path minus any recommended reserve light budget.
- 14. Block diagram showing all fiber cable interconnections and routing.

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15. Fiber Optic Cable Component Data:
 - a. Manufacturer and model number.
 - b. General data and description.
 - c. Engineering specifications and data sheet.
 16. Installation Details: Include modifications or further details required to adequately define installation of I&C components.
 17. List of spares, expendables, test equipment and tools.
 18. Additional Equipment Recommended: List of, and descriptive literature for, additional spares, expendables, test equipment and tools recommended. Include unit prices and total costs as specified in Section 01 29 00, Payment Procedures.
- B. Informational Submittals: For PIC equipment, provide Manufacturer's Certificate of Proper Installation and readiness for operation.
1. Owner Training Plan. Reference Section 01 43 33, Manufacturers' Field Services.
 2. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
 - a. Content and Format:
 - 1) Complete sets O&M manuals.
 - 2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PIC component.
 - 3) Final versions of Legend and Abbreviation Lists.
 - 4) Manual format in accordance with Section 01 78 23, Operation and Maintenance Data.
 - b. Include:
 - 1) Process and Instrumentation Diagrams: One reproducible copy of revised P&ID to reflect as-built PIC design.
 - 2) Refer to Article Shop Drawings for the following items:
 - a) Bill of Materials.
 - b) Catalog Cuts.
 - c) Component Data Sheets.
 - d) Panel Control Diagrams.
 - e) Panel Wiring Diagrams, one reproducible copy.
 - f) Panel Plumbing Diagrams, one reproducible copy.
 - g) Loop Diagrams, one reproducible copy.
 - h) Interconnecting Wiring Diagrams, one reproducible copy.
 - i) Application Software Documentation.

- 3) Device O&M manuals for components, electrical devices, and mechanical devices include:
 - a) Operations procedures.
 - b) Installation requirements and procedures.
 - c) Maintenance requirements and procedures.
 - d) Troubleshooting procedures.
 - e) Calibration procedures.
 - f) Internal schematic and wiring diagrams.
 - g) Component Calibration Sheets from field quality control calibrations.
 - 4) List of spares, expendables, test equipment and tools provided.
 - 5) List of additional spares, expendables, test equipment and tools recommended.
3. Performance Acceptance Tests (PAT) Submittals:
- a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
 - b. Final Test Procedures: Proposed test procedures, forms, and checklists.
 - c. Test Documentation: Copy of signed off test procedures when tests are completed.
4. Manufacturer's statement that installer is certified to perform installation Work for fiber optic cables.
5. Subcontractor Qualifications:
- a. FOCS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar systems.
 - 1) Statement of Experience: List of at least three fiber optic data communications systems comparable to system specified which have been furnished and placed into operation. For each system, provide following information:
 - a) Owner's name, address, telephone number, and name of current operations supervisor or other contact.
 - b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
 - c) System block diagram.
 - d) Dates when contract was signed, equipment was delivered, and system was accepted by Owner. Also, include originally scheduled completion date and if different from actual date, explain why.
 - e) Approximate value of listed FOCS provided in dollars.
 - f) Detailed horizontal and riser routing.

- g) Distribution frame arrangements.
 - h) Fiber and termination identification, including spares.
 - b. FOCS Subcontractor's Site Representative: Minimum of 5 years' experience installing similar systems.
 - c. Qualification of Personnel:
 - 1) Resumes identifying management and technical qualifications of supervisory, local service representative, and key personnel.
 - 2) Qualification data of firm and persons to demonstrate capabilities and experience in the following areas:
 - a) Fiber optic cable handling and placement techniques.
 - b) Fiber optic splicing and installation of connections.
 - c) Attenuation testing procedures.
 - d. Owner acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.
 - e. Sample of Network Test Report, minimum ten pages, that Contractor generated in a previous project.
 - f. Testing and acceptance plan, 30 days prior to beginning of testing.
 - g. Fiber Test Results: Documentation covering fiber facility testing, not later than 2 days after testing, showing:
 - 1) Manufacturer's tag of attenuation per fiber as recorded from OTDR reading before shipment.
 - 2) Attenuation of each fiber upon delivery to Site.
 - 3) Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
 - 4) Flux budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength. Include optical device manufacturer's optical light reserve margin in calculations, use 3dB if manufacturer does not have a recommend light budget reserve.
- 6. Fiber Optic Cable Manufacturer's Certificate of Proper Installation.
- 7. Fiber Optic Cable Manufacturer's suggested installation practice.
- 8. Operation and Maintenance Data: As specified in Section 01 78 23, Operations and Maintenance Data.

1.05 QUALITY ASSURANCE

- A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.

- B. Coordination Meetings:
1. In accordance with Section 01 31 13, Project Coordination.
 2. Location: Owner's Site.
 3. Attended By: Engineer, Owner, and Contractor.
 4. Minimum of one is required. Specific dates will be established in Progress Schedule.
 5. First Meeting: Within 36 days after Notice to Proceed.
- C. Fiber Optic Manufacturer Qualifications:
1. Cable:
 - a. ISO 9001 or QF TL 9000 registered, whichever applies to material.
 - b. Minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance.
 2. Housing: ISO 9001 and QF TL 9000 registered.
 3. Connector:
 - a. ISO 9001 or QF TL 9000 registered.
 - b. Minimum 10-year history of manufacturing and supporting connector technology that does not require epoxy or polishing in field.
 4. Jumper Cable: ISO 9001 and QF TL 9000 registered.
- D. Installer Qualifications:
1. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
 2. Certified by fiber cable manufacturer.
- E. Tester Qualifications: Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
1. Technician: Successfully attended training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof. Certificate may have been issued by the following organizations or an equivalent organization:
 - a. Manufacturer of fiber optic cable and fiber optic connectors.
 - b. Manufacturer of test equipment used for field certification.
 - c. Other independent training organizations acceptable to Owner.
- F. Provide connectors/coupling, splicing enclosures, mounting hardware, and miscellaneous accessories for fibers by same manufacturer.

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1.06 SPECIAL GUARANTEE, FIBER OPTIC CABLE

- A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this section found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Provide Site and warehouse storage facilities for PIC equipment.
- B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.
- C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- D. Cover panels and other elements that are exposed to dusty construction environments.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Standard Environmental Requirements: Unless otherwise noted, design equipment for continuous operation in these environments:
 - 1. Freestanding Panel and Consoles:
 - a. Inside, Air Conditioned: NEMA 1.
 - b. Inside: NEMA 12.
 - c. Outside: NEMA 4X.
 - 2. Smaller Panels and Assemblies (that are not Freestanding):
 - a. Inside, Air Conditioned: NEMA 12.
 - b. All Other Locations: NEMA 4X.
 - 3. Field Elements: Outside.
- B. Environmental Design Requirements: Following defines the types of environments referred to in the above.
 - 1. Inside, Air Conditioned:
 - a. Temperature:
 - 1) Normal: 60 to 80 degrees F.
 - 2) With Up to 4-Hour HVAC System Interruptions: 40 to 105 degrees F.

- b. Relative Humidity:
 - 1) Normal: 10 percent (winter) to 70 percent (summer).
 - 2) With Up to 4-Hour HVAC System Interruption: 10 to 100 percent.
 - c. NEC Classification: Nonhazardous.
 - 2. Inside:
 - a. Temperature: 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 95 percent noncondensing.
 - c. NEC Classification: Nonhazardous.
 - 3. Inside, Corrosive:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 95 percent noncondensing.
 - c. Corrosive Environment: Chlorine gas.
 - d. NEC Classification: Nonhazardous.
 - 4. Outside:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 95 percent noncondensing, freezing rain.
 - c. NEC Classification: Nonhazardous.
 - 5. Outside, Corrosive:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 95 percent noncondensing, freezing rain.
 - c. Corrosive Environment: Chlorine gas.
 - d. NEC Classification: Nonhazardous.
- C. Optical Fiber Cable and Cable Splice Centers:
- 1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.
 - 2. Outside, Overhead: Minus 40 degrees C to 80 degrees C.
 - 3. Outside, Aboveground in Conduit: Minus 40 degrees C to 80 degrees C.
 - 4. Inside: 0 degree C to 40 degrees C.

1.09 SEQUENCING AND SCHEDULING

- A. Activity Completion: The following is a list of key activities and their completion criteria:
- 1. Shop Drawings: Reviewed and approved.
 - 2. Quality Control Submittals: Reviewed and accepted.
 - 3. Hardware Delivery: Hardware delivered to Site and inventoried by Contractor.
 - 4. PAT: Completed and required test documentation accepted.

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- B. PIC Substantial Completion: When Engineer issues Certificate of Substantial Completion.
1. Prerequisites:
 - a. All PIC Submittals have been completed.
 - b. PIC has successfully completed PAT.
 - c. Owner training plan is on schedule.
 - d. All spares, expendables, and test equipment have been delivered to Owner.
- C. PIC Acceptance: When Engineer issues a written notice of Final Payment and Acceptance.
1. Prerequisites:
 - a. Certificate of Substantial Completion issued for PIC.
 - b. Punch-list items completed.
 - c. Final revisions to O&M manuals accepted.
 - d. Maintenance service agreements for PIC accepted by Owner.
- D. Prerequisite Activities and Lead Times: Do not start the following key Project activities until the prerequisite activities and lead times listed below have been completed and satisfied:

<u>Activity</u>	<u>Prerequisites and Lead Times</u>
Submittal reviews by Engineer	Engineer acceptance of Submittal breakdown and schedule.
Hardware purchasing, fabrication, and assembly	Associated Shop Drawing Submittals completed.
Shipment	Completion of PIC Shop Drawing Submittals and preliminary O&M manuals.
Owner Training	Owner training plan completed.
PAT	Startup, Owner training, and PAT procedures completed; notice 4 weeks prior to start.

PART 2 PRODUCTS

2.01 GENERAL

- A. PIC functions as shown on the Drawings and as required for each loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.

- B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment and materials.
 - 1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with Article Submittals.
 - 2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to: different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.

- C. Like Equipment Items:
 - 1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
 - 2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

- D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 LOOP SPECIFICATIONS

- A. Location: Article Supplements.
- B. Organization: By unit process and loop number.
- C. Functional Requirements for Control Loops:
 - 1. Shown on the Drawings, in Panel Control Diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on the Drawings.
 - 2. Supplemented by Loop Specifications.

D. Subheadings for Each Loop:

1. Functions: Clarifies functional performance of loop, including abstract of interlocks.
 - a. Components: Lists major components for each loop. Information listed includes tag numbers.
 - b. Component Identification Codes: Alphanumeric codes of required components. Refer to Component Specification referenced in Article Supplements.
 - c. Component Names and Options: Required to tailor general Component Specifications to specific application. For example, special materials, mounting, size, unit range, scale, setpoints, and controller options.

2.03 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on the enclosure face.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 1/2-inch white on black background, unless otherwise noted.

B. Component Nameplates—Panel Face: Component identification located on panel face under or near component.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

C. Component Nameplates—Back of Panel: Component identification located on or near component inside of enclosure.

1. Inscription: Component tag number.
2. Materials: Adhesive backed, laminated plastic.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches:

1. Inscription: Refer to:
 - a. Table under paragraph Standard Pushbutton Colors and Inscriptions.
 - b. Table under paragraph Standard Light Colors and Inscriptions.
 - c. P&IDs in the Drawings.

2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
 3. Letters: Black on gray or white background.
- E. Service Legends: Component identification nameplate located on face of component.
1. Inscription: As shown.
 2. Materials: Adhesive backed, laminated plastic.
 3. Letters: 3/16-inch white on black background, unless otherwise noted.
- F. Nametags: Component identification for field devices.
1. Inscription: Component tag number.
 2. Materials: 16-gauge, Type 304 stainless steel.
 3. Letters: 3/16-inch imposed.
 4. Mounting: Affix to component with 16- or 18-gauge stainless steel wire or stainless steel screws.

2.04 ELECTRICAL REQUIREMENTS

- A. In accordance with Division 26, Electrical.
- B. I&C and electrical components, terminals, wires, and enclosures: UL recognized or UL listed.
- C. Wires Within Enclosures:
1. ac Circuits:
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than 18 AWG.
 2. Analog Signal Circuits:
 - a. Type: 300-volt stranded copper, twisted shielded pairs.
 - b. Size: 18 AWG, minimum.
 3. Other dc Circuits.
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current carried, but not less than 18 AWG.
 4. Special Signal Circuits: Use manufacturer's standard cables.
 5. Wire Identification: Numbered and tagged at each termination.
 - a. Wire Tags: Machine printed, heat shrink.
 - b. Manufacturers:
 - 1) Brady PermaSleeve.
 - 2) Tyco Electronics.

- D. Wires entering or leaving enclosures, terminate and identify as follows:
1. Analog and discrete signal, terminate at numbered terminal blocks.
 2. Special signals, terminated using manufacturer's standard connectors.
 3. Identify wiring in accordance with Division 26, Electrical.
- E. Terminal Blocks for Enclosures:
1. Quantity:
 - a. Accommodate present and spare indicated needs.
 - b. Wire spare PLC and RTU I/O points to terminal blocks.
 - c. One wire per terminal for field wires entering enclosures.
 - d. Maximum of two wires per terminal for 18-WG wire for internal enclosure wiring.
 - e. Spare Terminals: 20 percent of all connected terminals, but not less than 5 per terminal block.
 2. General:
 - a. Connection Type: Screw compression clamp.
 - b. Compression Clamp:
 - 1) Complies with DIN-VDE 0611.
 - 2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
 - 3) Guides strands of wire into terminal.
 - c. Screws: Hardened steel, captive and self-locking.
 - d. Current Bar: Copper or treated brass.
 - e. Insulation:
 - 1) Thermoplastic rated for minus 55 to plus 110 degree C.
 - 2) Two funneled shaped inputs to facilitate wire entry.
 - f. Mounting:
 - 1) Standard DIN rail.
 - 2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - 3) End Stops: Minimum of one at each end of rail.
 - g. Wire preparation: Stripping only permitted.
 - h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
 - i. Marking System:
 - 1) Terminal number shown on both sides of terminal block
 - 2) Allow use of preprinted and field marked tags.
 - 3) Terminal strip numbers shown on end stops.
 - 4) Mark terminal block and terminal strip numbers as shown on Panel Control Diagrams and Loop Diagrams.
 - 5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

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3. Terminal Block, General-Purpose:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 30 amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Spacing: 0.25 inch, maximum.
 - g. Test Sockets: One screw test socket 0.079-inch diameter.
 - h. Manufacturer and Product: Entrelec; Type M4/6.T.
4. Terminal Block, Ground:
 - a. Wire Size: 22 AWG to 12 AWG.
 - b. Rated Wire Size: 12 AWG.
 - c. Color: Green and yellow body.
 - d. Spacing: 0.25 inch, maximum.
 - e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
 - f. Manufacturer and Product: Entrelec; Type M4/6.P.
5. Terminal Block, Fused, 24V dc:
 - a. Rated Voltage: 600V dc.
 - b. Rated Current: 16-amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: LED diode 24V dc.
 - h. Spacing: 0.512 inch, maximum.
 - i. Manufacturer and Product: Entrelec; Type M10/13T.SFL.
6. Terminal Block, Fused, 120V ac:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 16-amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: Neon Lamp 110V ac.
 - h. Leakage Current: 1.8 mA, maximum.
 - i. Spacing: 0.512 inch, maximum
 - j. Manufacturer and Product: Entrelec; Type M10/13T.SFL.

F. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.

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2. Ground bus grounded at a common signal ground point in accordance with National Electrical Code requirements.
 3. Single Point Ground for Each Analog Loop:
 - a. Locate at dc power supply for loop.
 - b. Use to ground wire shields for loop.
 4. Ground terminal block rails to ground bus.
- G. Analog Signal Isolators: Furnish signal isolation for analog signals that are sent from one enclosure to another. Do not wire in series instruments on different panels, cabinets, or enclosures.
- H. Power Distribution Within Panels:
1. Feeder Circuits:
 - a. One or more 120V ac, 60-Hz feeder circuits as shown on the Drawings.
 - b. Make provisions for feeder circuit conduit entry.
 - c. Furnish terminal board for termination of wires.
 2. Power Panel: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
 - a. Locate to provide clear view of and access to breakers when door is open.
 - b. Breaker Sizes: Coordinate such that fault in branch circuit will blow only branch breaker but not trip the main breaker.
 - 1) Branch Circuit Breaker: 15 amps at 250V ac.
 - c. Breaker Manufacturers and Products: Refer to Division 26, Electrical.
 3. Circuit Wiring: P&IDs and Control Diagrams on the Drawings show function only. Use following rules for actual circuit wiring:
 - a. Devices on Single Circuit: 20, maximum.
 - b. Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
 - c. Branch Circuit Loading: 12 amperes continuous, maximum.
 - d. Panel Lighting and Service Outlets: Put on separate 15-amp, 120V ac branch circuit.
 - e. Provide 120V ac plugmold for panel components with line cords.
- I. Signal Distribution:
1. Within Panels: 4 mA to 20 mA dc signals may be distributed as 1 to 5V dc.
 2. Outside Panels: Isolated 4 mA to 20 mA dc only.
 3. All signal wiring twisted in shielded pairs.

J. Relays:

1. General:
 - a. Relay Mounting: Plug-in type socket.
 - b. Relay Enclosure: Furnish dust cover.
 - c. Socket Type: Screw terminal interface with wiring.
 - d. Socket Mounting: Rail.
 - e. Provide holddown clips.
2. Signal Switching Relay:
 - a. Type: Dry circuit.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 0 to 5 amps at 28V dc or 120V ac.
 - d. Contact Material: Gold or silver.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 0.9 watts (dc), 1.2VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Seal Type: Hermetically sealed case.
 - k. Manufacturer and Product: Potter and Brumfield;
Series KH/KHA.
3. Control Circuit Switching Relay, Nonlatching:
 - a. Type: Compact general-purpose plug-in.
 - b. Contact Arrangement: 3 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 240V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Push to test button.
 - k. Manufacturer and Product: Potter and Brumfield; Series KUP.

K. Power Supplies:

1. Furnish to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
 - a. Protect instruments from damage due to power supply failure.
 - b. Protect power supply from damage due to external failure.

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4. Enclosures: NEMA 1 in accordance with NEMA 250.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
 - a. Type: Indicating.
 - b. Mount so fuses can be easily seen and replaced.

L. Internal Panel Lights for Freestanding Panels:

1. Type: Switched 100-watt incandescent back-of-panel lights.
2. Quantity: One light for every 4 feet of panel width.
3. Mounting: Inside and in the top of back-of-panel area.
4. Protective metal shield for lights.

M. Service Outlets for Freestanding Panels:

1. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
2. Quantity:
 - a. For panels 4 feet wide and smaller: One.
 - b. For panels wider than 4 feet: One for every 4 feet of panel width, two minimum per panel.
3. Mounting: Evenly spaced along back-of-panel area.

N. Internal Panel Lights and Service Outlets for Smaller Panels:

1. Internal Panel Light: Switched LED light.
2. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:

O. Standard Pushbutton Colors and Inscriptions: Use following color code and inscriptions for pushbuttons, unless otherwise noted on the Drawings.

Tag Function	Inscription(s)	Color
OO	ON OFF	Red Green
OC	OPEN CLOSE	Red Green
OCA	OPEN CLOSE AUTO	Red Green White

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Tag Function	Inscription(s)	Color
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Red Green
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

1. Lettering Color:
 - a. Black on white and yellow buttons.
 - b. White on black, red, and green buttons.

- P. Standard Light Colors and Inscriptions: Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted on the Drawings.

Tag Function	Inscription(s)	Color
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow

1. Lettering Color:
 - a. Black on white and amber lenses.
 - b. White on red and green lenses.

2.05 MULTIMODE FIBER OPTIC CABLE

- A. General 62.5-micron, graded-index for use in backbone and horizontal distribution subsystems, meets or exceeds the requirements of TIA 568-C.3, including the following specifications:
1. Maximum Mean Fiber Loss:
 - a. 3.5 dB per km at 850 nm.
 - b. 1.5 dB per km at 1,300 nm.
 2. Minimum OFL Bandwidth:
 - a. OM1-200 MHz•km minimum at 850 nm; TIA 492AAAB.
 - b. 500 MHz•km minimum at 1,300 nm.
 3. Distance Capacity per IEEE 802.3:
 - a. 100Mbit Ethernet: OM2300m at 850 nm and 2000m at 1,310 nm.
 - b. 1 gbit Ethernet:
 - 1) OM1: 300m at 850 nm and 550 at 1,310 nm.
 - c. 10 gbit Ethernet—10km at 850 nm and 40km at 1,310 nm:
 - 1) OM1: 33m at 850 nm and 300 at 1,310 nm.
- B. Type 62.5 OM1, Indoor/Outdoor Cable, requirements in addition to general requirements above:
1. Individual Fibers: 62.5/125/250/900 microns.
 2. Assembly:
 - a. Distribution Style with core of individually tight-buffered fibers surrounded by nonmetallic sheath.
 - b. Cable: Comply with ICEA S-83-596.
 3. Protective Covering: Flame retardant, oil resistant, chemical resistant, and water resistant fluoropolymer outer jacket.
 4. NEC/UL Listing: OFNP.
 5. Manufacturers and Products:
 - a. Corning Freedom One Riser Cables.
 - b. Corning Freedom One Plenum Cables.
 - c. No substitutes.

2.06 FIBER OPTIC CONNECTORS

- A. General:
1. Connect all fibers and terminate at equipment and patch panels.
 2. Comply with TIA/EIA 604-2, TIA/EIA 604-3, TIA/EIA 604-12, and TIA 568-C.3.
 3. ST Bayonet Style connectors or as required for proper mating connection.
 4. Pull Strength: 0.2 N minimum.

5. Durability: Sustain minimum 500 mating cycles without violating other requirements.
 - a. Ferrules: Free-floating low loss ceramic.
 - b. Polarizing key on duplex connector systems.
6. Attenuation:
 - a. In accordance with TIA 568-C.3.
 - b. Maximum of 0.5 dB per connector pair.
7. Manufacturers:
 - a. Corning.
 - b. Ortronics.
 - c. AMP Netconnect.

2.07 SPARE PARTS

Description	Percent of Each Type and Size Used	No Less Than
dc power supplies	20	2
Fuses	20	5
Indicating light bulb	20	10
Relays	20	3
Terminal Blocks	10	10
Hand Switches	10	5

2.08 FABRICATION

- A. General:
 1. Panels with external dimensions and instruments arrangement as shown on the Drawings or in Control Panel List.
 2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code, state and local codes, NEMA, ANSI, UL, and ICECA.
 3. Fabricate panels, install instruments, wire, and plumb, at the PIC factory.
 4. Electrical Work: In accordance with Division 26, Electrical.
- B. Factory Assembly: Assemble panels at the manufacturer’s factory. No fabrication other than correction of minor defects or minor transit damage shall be done on panels at Site.
- C. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

D. Wiring Within PIC Panels:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Abrasion protection for wire bundles which pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
 - a. Locking-fork-tongue or ring-tongue lugs.
 - b. Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
 - c. Wires terminated in a crimp lug, maximum of one.
 - d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
 - a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
 - b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Ducts Fill: Do not exceed manufacturer's recommendation.

E. Temperature Control:

1. Provide Heat Load Calculations for all control panels.
2. Freestanding Panels:
 - a. Non-ventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel or on panel.
 - b. Ventilated Panels:
 - 1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel or on panel.
 - 2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.

- 3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
- 4) Louver Construction: Stamped sheet metal.
- 5) Ventilation Fans:
 - a) Furnish where required to provide adequate cooling.
 - b) Create positive internal pressure within panel.
 - c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
- 6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
3. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel or in panel face.
4. Space Heaters:
 - a. Thermostatically controlled to maintain internal panel temperatures above dew point.
 - b. Required for following panels: All.

F. Freestanding Panel Construction:

1. Materials: Sheet steel, unless otherwise shown on the Drawings with minimum thickness of 10-gauge, unless otherwise noted.
2. Panel Fronts:
 - a. Fabricated from a single piece of sheet steel, unless otherwise shown on the Drawings.
 - b. No seams or bolt heads visible when viewed from front.
 - c. Panel Cutouts: Smoothly finished with rounded edges.
 - d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
3. Internal Framework:
 - a. Structural steel for instrument support and panel bracing.
 - b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Doors: Full height, fully gasketed access doors where shown on the Drawings.
 - a. Latches: Three-point, Southco Type 44.
 - b. Handles: "D" ring, foldable type.
 - c. Hinges: Full length, continuous, piano type, steel hinges with stainless steel pins.

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- d. Rear Access Doors: Extend no further than 24 inches beyond panel when opened to 90-degree position.
- e. Front and Side Access Doors: As shown on the Drawings.

G. Non-freestanding Panel Construction:

- 1. Based on environmental design requirements required and referenced in Article Environmental Requirements, provide the following:
 - a. For panels listed as inside, air conditioned:
 - 1) Enclosure Type: NEMA 12 in accordance with NEMA 250.
 - 2) Materials: Steel.
 - b. For all other panels:
 - 1) Enclosure Type: NEMA 4X in accordance with NEMA 250.
 - 2) Materials: Type 316 stainless steel.
- 2. Metal Thickness: 14-gauge, minimum.
- 3. Doors:
 - a. Rubber-gasketed with continuous hinge.
 - b. Stainless steel lockable quick-release clamps.
- 4. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Rittal.

H. Factory Finishing:

- 1. Enclosures:
 - a. Stainless Steel and Aluminum: Not painted.
 - b. Nonmetallic Panels: Not painted.
 - c. Steel Panels:
 - 1) Sand panel and remove mill scale, rust, grease, and oil.
 - 2) Fill imperfections and sand smooth.
 - 3) Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
 - 4) Sand surfaces lightly between coats.
 - 5) Dry Film Thickness: 3 mils, minimum.
- 2. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

2.09 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

- 1. Northern Instruments; Model Zerust VC.
- 2. Hoffmann Engineering Co; Model A-HCI.

2.10 SOURCE QUALITY CONTROL

- A. Scope: Inspect and test entire PIC to ensure it is ready for shipment, installation, and operation.
- B. Location: Manufacturer's factory or Engineer approved staging Site.
- C. Test: Exercise and test all functions.
- D. Temporary PLC software configuring to allow PLC testing.

2.11 ELECTRICAL TRANSIENT PROTECTION

- A. General:
 - 1. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
 - 2. Implementation: Provide, install, coordinate, and inspect grounding of surge suppressors at:
 - a. Connection of ac power to PIC equipment including panels, consoles assemblies, and field mounted analog transmitters and receivers.
 - b. At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.
 - 3. Construction: First-stage high energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance. Includes grounding wire, stud, or terminal.
 - 4. Response: 5 nanoseconds maximum.
 - 5. Recovery: Automatic.
 - 6. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
- B. Suppressors on 120V ac Power Supply Connections:
 - 1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE 587 Category B test waveform.
 - 2. First-Stage Clamping Voltage: 350 volts or less.
 - 3. Second-Stage Clamping Voltage: 210 volts or less.
 - 4. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.

C. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8 microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
 - a. dc Clamping Voltage: 20 to 40 percent above operating voltage for circuit.
 - b. dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
 - c. Maximum Loop Resistance: 18 ohms per conductor.

D. Physical Characteristics:

1. Mounted in Enclosures: Encapsulated in flame retardant epoxy.
2. For Analog Signals Lines: EDCO PC-642 or SRA-64 series.
3. For 120V ac Lines: EDCO HSP-121.
4. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 series.
5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
 - a. Enclosure: NEMA 4X fiberglass or Type 316 stainless steel with door.
 - 1) Maximum Size: 12 inches by 12 inches by 8 inches deep.
 - b. Manufacturer and Product: EDCO; SLAC series.

- E. Installation and Grounding of Suppressors: As shown. See Surge Suppressor Installation Details. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

PART 3 EXECUTION

3.01 EXAMINATION

- A. For equipment not provided by PIC, but that directly interfaces with the PIC, verify the following conditions:
1. Proper installation.
 2. Calibration and adjustment of positioners and I/P transducers.
 3. Correct control action.
 4. Switch settings and dead bands.
 5. Opening and closing speeds and travel stops.
 6. Input and output signals.

3.02 INSTALLATION

- A. Material and Equipment Installation: Retain a copy of manufacturers' instructions at Site, available for review at all times.
- B. Electrical Wiring: As specified in Division 26, Electrical.
- C. Mechanical Systems:
 - 1. Drawings for PIC Mechanical Systems are diagrammatic and not intended to specifically define element locations or piping and tubing run lengths. Base materials and installations on field measurements.
 - 2. Copper and Stainless Steel Tubing Support: Continuously supported by an aluminum tubing raceway system.
 - 3. Plastic Tubing Supports: Except as shown on the Drawings, provide continuous support in conduits or by aluminum tubing raceway system.
 - 4. Install tubing conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
 - 5. Tubing and Conduit Bends:
 - a. Tool-formed without flattening, and all of same radius.
 - b. Bend Radius: Equal to or larger than conduit and tubing manufacturer's recommended minimum bend radius.
 - c. Slope instrument connection tubing in accordance with installation details.
 - d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
 - e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
 - f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
 - g. Blow debris from inside of tubing.
 - h. Make up and install fittings in accordance with manufacturer's recommendations. Verify makeup of tube fittings with manufacturer's inspection gauge.
 - i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
 - j. Run tubing to allow, for example, clear access to doors, controls, and control panels; and to allow for easy removal of equipment.
 - k. Provide separate support for components in tubing runs.

- l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
- m. Keep tubing and conduit runs at least 12 inches from hot pipes.
- n. Locate and install tubing raceways in accordance with manufacturer's recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
- o. Securely attach tubing raceways to building structural members.
6. Enclosure Lifting Rings: Remove rings following installation and plug holes.

D. Removal or Relocation of Materials and Equipment:

1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

3.03 FIBER OPTIC CABLE INSTALLATION

A. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are indicated on the Drawings.
2. Installation by manufacturer's certified installer.
3. Install cables in accordance with manufacturer's requirements.
4. Install cable directly from shipping reels. Ensure that cable is:
 - a. Not dented, nicked, or kinked.
 - b. Not subjected to pull stress greater than manufacturer's specification.
 - c. Not bent to a radius below manufacturer's minimum bend radius.
 - d. Not subjected to treatment that may damage fiber strands during installation.
5. Cables per Innerduct: One cable maximum.
6. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Engineer.
7. Connector: Insertion loss on multimode connections exceeding 0.5 dB and 0.4 dB on single-mode connections not permitted.
8. Identification:
 - a. Identify cable on both ends, in access holes, and pull points.
 - b. In accordance with TIA 606.
9. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.

10. Access Holes:
 - a. Provide supports for cables in access and handholes at minimum 24 inches.
 - b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

B. Cable Terminations:

1. In accordance with TIA 568-C.3.
2. Fan out fiber cable to allow direct connectorization of connectors.
 - a. Sleeve over individual fibers with transparent furcation tubes.
 - b. At point of convergence of furcation tubes, provide strain relief with metal or high-density plastic fan-out collar.
3. Break-out Kits:
 - a. Terminate cables using manufacturer-supplied break-out kits.
 - b. Terminate in accordance with manufacturer's recommendations.
4. Slack:
 - a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
 - b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.
5. Connectors:
 - a. Terminate 100 percent fibers in each cable to specified connector.
 - b. Connect into fiber management system.

3.04 FIELD QUALITY CONTROL FIBER OPTIC CABLE

A. General:

1. Advise Engineer at least 48 hours in advance of each test. Engineer shall have option to witness and participate actively in tests.
2. In accordance with Division 01, General Requirements.
3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.
4. Outlets, cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.
5. Testing performed on incomplete systems shall be redone on completion of the Work.
6. Document Test Results: Confirm each cable has at least specified number of fibers that meet standards, in accordance with As-Built Fiber Optic Cable Installation form included as Supplement to this section.
7. Confirm quantities and sizes of conduit and innerduct, in accordance with As-Built Conduit/Innerduct Installation form included as Supplement to this section.

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B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.
2. Optical Fiber Cable Testers:
 - a. Field test instrument shall be within calibration period recommended by manufacturer.
 - b. Optical Loss Test Set (OLTS):
 - 1) Multimode Optical Fiber Light Source:
 - a) Provide dual LED light sources with central wavelengths of 850 nm (plus or minus 30 nm) and 1,300 nm (plus or minus 20 nm).
 - b) Output Power: Minus 20 dBm minimum.
 - c) Meet launch requirements of TIA/EIA 455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap, as described in Clause 11 of TIA 568-C.3, with Category 1 light source.
 - d) Manufacturer: Fluke Networks.
 - 2) Power Meter:
 - a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.
 - b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
 - c) Store reference power measurement.
 - d) Save at least 100 results in internal memory.
 - e) PC interface (serial or USB).
 - f) Manufacturer: Fluke Networks.
 - 3) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.
3. Optical Time Domain Reflectometer (OTDR):
 - a. Bright, color transmissive LCD display with backlight.
 - b. Rechargeable for 8 hours of normal operation.
 - c. Weight with battery and module of not more than 4.5 pounds and volume of not more 200 cubic inches.
 - d. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
 - e. Serial and USB ports to transfer data to PC.
 - f. Multimode OTDR:
 - 1) Wavelengths: 850 nm (plus or minus 20 nm) and 1,300 nm (plus or minus 20 nm).
 - 2) Event Dead Zone: 1 meter maximum at 850 nm and 2 meters maximum at 1,300 nm.
 - 3) Attenuation Dead Zone: 6 meters maximum at 850 nm and 15 meters maximum at 1,300 nm.

- 4) Distance Range: 2,000 meters minimum.
 - 5) Dynamic Range: Minimum 10 dB at 850 nm and 1,300 nm.
 - g. Manufacturer: Fluke Networks.
 4. Fiber Microscope:
 - a. Magnification: 250X or 400X for end-face inspection.
 - b. Manufacturer: Fluke Networks.
 5. Integrated OLTS, OTDR, and Fiber Microscope:
 - a. Test equipment that combines into one instrument such as OLTS, OTDR, and fiber microscope may be used.
 - b. Manufacturer: Fluke Networks.
- C. Conduit Test:
1. Test and seal spare conduits.
 2. Conduit and Innerduct Testing:
 - a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
 - b. If conduit is restricted over full length, advise Engineer.
 3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.
- D. Cable Testing:
1. Test procedures and field test instruments shall comply with applicable requirements of:
 - a. LIA Z136.2.
 - b. TIA/EIA 455-78.
 - c. TIA/EAI 455-133.
 - d. TIA 526-7.
 - e. TIA 526-14.
 - f. TIA 568-C.1.
 - g. TIA 568-C.3.
 - h. TIA TSB 140.
 2. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.
 3. Verify condition of fiber end face.
 4. Perform on each cabling link (connector to connector).
 5. Perform on each cabling channel (equipment to equipment).
 6. Do not include active devices or passive devices within link or channel other than cable, connectors, and splices. For example, link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

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7. Document Tests:
 - a. OLTS dual wavelength attenuation measurements for multimode links and channels.
 - b. OTDR traces and event tables for multimode links and channels.

E. Fiber Testing Parameters:

1. Each cabling link shall be in compliance with the following test limits:
 - a. Optical Loss Testing:
 - 1) Backbone (single-mode and multimode) Link:
 - a) Calculate link attenuation by the formulas specified in TIA 568-C.1.
 - b) Values for Attenuation Coefficient (dB/km) are listed in the table below:

Attenuation Coefficient				
Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Multimode 50/125 μm	850	3.5	1300	1.5

- b. OTDR Testing:
 - 1) Reflective Events: Maximum 0.75 dB.
 - 2) Nonreflective Events: Maximum 0.3 dB.
- c. Magnified Endface Inspection:
 - 1) Visually inspect fiber connections for end-face quality.
 - 2) Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Diagnosis and Correction:

1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.
2. Link or channel that fails these requirements shall be diagnosed and corrected.
3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.
4. Provide final and passing result of tests for links and channels.

- G. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of Owner.

H. Test Execution:

1. Optical Fiber Cable Testing:
 - a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
 - b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
 - 1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
 - c. Perform Testing:
 - 1) On each cabling segment (connector to connector).
 - 2) On each cabling channel (equipment to equipment).
 - 3) Using high-quality test cords of same fiber type as cabling under test.
 - a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
 - b) Test cords for OTDR testing shall be approximately 100 meters for launch cable and at least 25 meters for receive cable.
2. Optical Loss Testing (OLTS):
 - a. Backbone Link:
 - 1) Test multimode at 850 nm and 1,300 nm in accordance with TIA 526-14A, Method B, One Reference Jumper or equivalent method.
 - 2) Perform tests in both directions.
3. OTDR Testing:
 - a. Test backbone, horizontal, and centralized links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
 - 1) Multimode: 850 nm and 1,300 nm.
 - b. Test each fiber link and channel in one direction.
 - c. Install launch cable between OTDR and first link connection.
 - d. Install receive cable after last link connection.
4. Length Measurement:
 - a. Record length of each fiber.
 - b. Measure optical length using OLTS or OTDR.
5. Polarity Testing:
 - a. Test paired duplex fibers in multifiber cables to verify polarity in accordance with subclause 10.3 of TIA/EIA 568-C.1.
 - b. Verify polarity of paired duplex fibers using OLTS.

6. Test Results Documentation:
 - a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, “as saved in the field-test instrument.” The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
 - b. Available for inspection by Owner or Owner’s representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
 - c. Database for project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD-ROM prior to Owner acceptance of building. CD-ROM shall include software tools required to view, inspect, and print test reports.
 - d. Circuit IDs reported by test instrument shall match specified label identification.
 - e. Provide in electronic database for each tested optical fiber with the following information:
 - 1) Identification of Site.
 - 2) Name of test limit selected to execute stored test results.
 - 3) Name of personnel performing test.
 - 4) Date and time test results were saved in memory of tester.
 - 5) Manufacturer, model, and serial number of field test instrument.
 - 6) Version of test software and version of test limit database held within test instrument.
 - 7) Fiber identification number.
 - 8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.
 - 9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.
 - 10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.
 - 11) Length for each optical fiber as calculated by the OTDR.
 - 12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.

3.05 FIELD FINISHING

- A. Refer to Section 09 90 00, Painting and Coatings.

3.06 FIELD QUALITY CONTROL

- A. Startup and Testing Team:
1. Thoroughly inspect installation, termination, and adjustment for components and systems.
 2. Complete onsite tests.
 3. Complete onsite training.
 4. Provide startup assistance.
- B. Operational Readiness Inspections and Calibrations: Prior to startup, inspect and test to ensure that entire PIC is ready for operation.
1. Loop/Component Inspections and Calibrations:
 - a. Check PIC for proper installation, calibration, and adjustment on a loop-by-loop and component-by-component basis.
 - b. Prepare component calibration sheet for each active component (except simple hand switches, lights, gauges, and similar items).
 - 1) Project name.
 - 2) Loop number.
 - 3) Component tag number.
 - 4) Component code number.
 - 5) Manufacturer for elements.
 - 6) Model number/serial number.
 - 7) Summary of functional requirements, for example:
 - a) Indicators and recorders, scale and chart ranges.
 - b) Transmitters/converters, input and output ranges.
 - c) Computing elements' function.
 - d) Controllers, action (direct/reverse) and control modes (PID).
 - e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
 - 8) Calibrations, for example:
 - a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
 - b) Discrete Devices: Actual trip points and reset points.
 - c) Controllers: Mode settings (PID).
 - 9) Space for comments.
 - c. These inspections and calibrations will be spot checked by Engineer.

- C. Performance Acceptance Tests (PAT): These are the activities that Section 01 91 14, Equipment Testing and Facility Startup, refers to as Performance Testing.
1. General:
 - a. Test all PIC elements to demonstrate that PIC satisfies all requirements.
 - b. Test Format: Cause and effect.
 - 1) Person conducting test initiates an input (cause).
 - 2) Specific test requirement is satisfied if correct result (effect) occurs.
 - c. Procedures, Forms, and Checklists:
 - 1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
 - 2) Describe each test item to be performed.
 - 3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
 - d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Engineer and Contractor.
 - e. Conducting Tests:
 - 1) Provide special testing materials, equipment, and software.
 - 2) Wherever possible, perform tests using actual process variables, equipment, and data.
 - 3) If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
 - 4) Define simulation techniques in test procedures.
 - f. Coordinate PIC testing with Owner and affected Subcontractors.
 - 1) Excessive Test Witnessing: Refer to Supplementary Conditions.
 2. Test Requirements:
 - a. Once facility has been started up and is operating, perform a witnessed PAT on complete PIC to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.
 - b. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
 - c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.

- d. Make updated versions of documentation required for PAT available to Engineer at Site, both before and during tests.
- e. Make one copy of O&M manuals available to Engineer at the Site both before and during testing.
- f. Refer to referenced examples of PAT procedures and forms in Article Supplements.

3.07 TRAINING

A. General:

1. Provide an integrated training program to meet specific needs of Owner's personnel.
2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
3. Provide instruction on one working shift(s) as needed to accommodate the Owner's personnel schedule.
4. Owner reserves the right to make and reuse video tapes of training sessions.

B. Operations and Maintenance Training:

1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
2. Use equipment similar to that provided or currently owned by Owner.
3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.

C. Operations Training:

1. Training Session Duration: One 8-hour instructor days per site.
2. Number of Training Sessions: One per site.
3. Location: Sites.
4. Content: Conduct training on loop-by-loop basis.
 - a. Loop Functions: Understanding of loop functions, including interlocks for each loop.
 - b. Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
 - c. Interfaces with other control systems.

D. Maintenance Training:

1. Training Session Duration: One 8-hour instructor days per site.
2. Number of Training Sessions: One per site.

3. Location: Project Sites.
4. Content: Provide training for each type of component and function provided.
 - a. Loop Functions: Understanding details of each loop and how they function.
 - b. Component calibration.
 - c. Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
 - d. Troubleshooting and diagnosis for components.
 - e. Replacing lamps, chart paper, fuses.
 - f. Component removal and replacement.
 - g. Periodic maintenance.

3.08 CLEANING/ADJUSTING

- A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.
- B. Cleaning:
 1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
 2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.09 PROTECTION

- A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.
- B. Periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules just prior to Final Payment and Acceptance.

3.10 SUPPLEMENTS

- A. Supplements listed below, following "End of Section," are part of this Specification.
 1. Component Specifications.
 2. Instrument and Control Panel List.
 3. Loop Specifications.
 4. Instrument Calibration Sheet: Provides detailed information on each instrument (except simple hand switches, lights, and similar items).

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5. I&C Valve Adjustment Sheet: Each sheet shows detailed information for installation, adjustment, and calibration of a given valve.
6. Performance Acceptance Test Sheet: Describes the PAT for a given loop. The format is mostly free form.
 - a. Lists the requirements of the loop.
 - b. Briefly describes the test.
 - c. Cites expected results.
 - d. Provides space for check off by witness.
7. As-Built Fiber Optic Cable Installation Form.
8. MR Systems Quote Q22-9855-R1 (Hooper Only).
9. MR Systems Quote Q22-9855-R1 (Hicks Only).

END OF SECTION

COMPONENT SPECIFICATIONS

- A. A41 Analyzer Element and Transmitter, UV Transmittance:
1. Provide continuous reading, UVT spectrophotometer probe suitable for measurement of UVT utilizing 180 degree absorption measurement methods for the purposes of calculating UV Dose for UV disinfection reactors. The analyzer shall also be capable of simultaneous measurement of EPA 180.1 turbidity utilizing 90 degree scattering measurement method. The unit shall include a lamp, sensor, analyzer, and transmitter.
 2. Performance:
 - a. UVT Range: 0 to 100 percent UVT or 0 – 2 UVA at 254 nm based on nominal 1-cm path length.
 - b. UVT Accuracy: +/- 1% UVT.
 - c. Turbidity Range: 0 to 5 NTU.
 - d. Turbidity Accuracy: 0.02 NTU.
 - e. TOC Range: 0-25 mg/L TOC.
 - f. TOC Accuracy: 0.1+/- mg/L TOC.
 - g. Lamp Life: 3 years, min.; 5,000 hrs min.
 - h. Measurement Frequency: 1 per 60 seconds min.
 3. Accessories:
 - a. Automatic or manual calibration options for flowrate.
 - b. Automatic mechanical cleaning system with manual option.
 - c. Fixed position flow cell independently mounted to support panel and supply piping, with wiper.
 - d. 10 ft, IP68 cable with plug to connect analyzer to local monitoring panel/transmitter for signals and power.
 4. Mechanical:
 - a. Sample Flow Rate: 0.25 - 2 gpm.
 - b. Sample Pressure: 2 - 20 psig.
 5. Environmental:
 - a. Operating Temperature (Sample): 0.5 degrees C to 35 degrees C.
 - b. Operating Temperature (Ambient): 0 degrees C to 60 degrees C.
 - c. Humidity: 0 to 100 percent Condensing.
 6. Required Spare Parts/Support:
 - a. 2-person days installation/start-up support and operator training by UVT analyzer supplier.
 - b. 2 additional days and 2 trips allowance for additional commissioning assistance and troubleshooting for the UV system integration.
 - c. 3 year manufacturer standard warranty.
 7. Local Indication/Transmitter:
 - a. Source Power: 120 VAC.

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- b. Electrical Enclosure: IP65/NEMA 4, wall mountable enclosure, PP plastic.
 - c. Touch screen interface.
 - d. Signal Outputs to SCADA:
 - 1) Ethernet; RS 485 Modbus RTU; 420mA; relay.
 - 2) Low lamp output.
 - 3) System fault.
 - 4) Other data as defined by Owner.
 - e. Inputs:
 - 1) UVT Analyzer Type A1 data.
 - 2) UVT Analyzer Type A2 data.
8. Manufacturer/Model:
- a. Analyzer:
 - 1) I::scan NTU/FTU + 254 equivalent TOC (mg/L) and UV transmittance (% transmittance per 1 cm), S::can Inc., Cambridge, MA.
 - 2) No "or-equals."
 - b. Indicator/Transmitter
 - 1) S::can Con:cube. S::can, Cambridge, MA.
 - 2) No "or-equals".

B. F4 Flow Element and Transmitter, Electromagnetic:

- 1. General:
 - a. Function: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
 - b. Type:
 - 1) Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
 - 2) Full bore meter with magnetic field traversing entire flow-tube cross section.
 - 3) Unacceptable are insert magmeters or multiple single point probes inserted into a spool piece.
 - c. Parts: Flow element, transmitter, interconnecting cables, and mounting hardware. Other parts as noted.
- 2. Service:
 - a. Stream Fluid:
 - 1) As noted.
 - 2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
 - b. Flow Stream Descriptions: If and as described below.

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3. Operating Temperature:
 - a. Element:
 - 1) Ambient: Minus 5 degrees F to 140 degrees F, typical, unless otherwise noted.
 - 2) Process: Minus 5 degrees F to 140 degrees F, typical, unless otherwise noted.
 - b. Transmitter:
 - 1) Ambient: Minus 5 degrees F to 140 degrees F, typical, unless otherwise noted.
 - 2) Storage: 15 degrees F to 120 degrees F, typical, unless otherwise noted.
4. Performance:
 - a. Flow Range: As noted.
 - b. Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 to 30 feet per second.
 - c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
5. Features:
 - a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
 - b. No obstructions to flow.
 - c. Very low pressure loss.
 - d. Measures bi-directional flow.
6. Process Connection:
 - a. Meter Size (diameter inches): As noted.
 - b. Connection Type: 150-pound ANSI raised-face flanges; AWWA C207, Table 2 Class D; or wafer style depending on meter size, unless otherwise noted.
 - c. Flange Material: Carbon steel, unless otherwise noted.
7. Power (Transmitter): 120V ac, 60-Hz, unless otherwise noted.
8. Element:
 - a. Meter Tube Material: Type 304 or 316 stainless steel, unless otherwise noted.
 - b. Liner Material:
 - 1) Polyurethane.
 - 2) For potable water service, must have appropriate approvals.
 - c. Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
 - d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
 - e. Electrode Material: Type 316 stainless steel or Hastelloy C, unless otherwise noted.

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- f. Grounding Ring:
 - 1) Required, unless otherwise noted.
 - 2) Quantity: Two, unless otherwise noted.
 - 3) Material: Type 316 stainless steel, unless otherwise noted.
 - g. Enclosure: NEMA 4X, minimum, unless otherwise noted.
 - h. Submergence:
 - 1) Temporary: If noted.
 - 2) Continuous (up to 10 feet depth), NEMA 6P/IP68: If noted.
 - i. Direct Buried (3 to 10 feet): If noted.
 - j. Hazardous Area Certification:
 - 1) Class 1, Division 2, Groups A, B, C, D: If noted.
 - 2) Class 1, Division 1, Groups A, B, C, D, and FM approved: If noted.
 - 3) Class 1, Division 1, Groups C, D, and FM approved: If noted.
9. Transmitter:
- a. Mounting: Surface (wall), unless otherwise noted.
 - b. Display: Required, unless otherwise noted.
 - 1) Digital LCD display, indicating flow rate and total.
 - 2) Bi-directional Flow Display: Required, unless otherwise noted.
 - a) Forward and reverse flow rate.
 - b) Forward, reverse and net totalization.
 - c. Parameter Adjustments: By keypad or non-intrusive means.
 - d. Enclosure: NEMA 4X, minimum, unless otherwise noted.
 - e. Empty Pipe Detection:
 - 1) If noted.
 - 2) Drives display and outputs to zero when empty pipe deleted.
10. Signal Interface (at Transmitter):
- a. Analog Output:
 - 1) Isolated 4 to 20 mA dc for load impedance from 0 to at least 500 ohms minimum for 24V dc supply.
 - 2) Supports Superimposed Digital HART protocol: If noted.
 - b. Discrete Outputs: If noted.
 - 1) Two discrete outputs, typical, rated for up to 30 volts, typical.
 - 2) Programmable as noted for the following typical parameters:
 - a) High/low flow rates, percent of range, empty pipe zero, fault conditions, forward/reverse, etc.
 - c. Discrete Input: If noted.
 - 1) Contact closure, configured as noted for the following typical parameters: reset totalizer, change range, hold output constant, drive output to zero, and low flow cutoff, etc.
 - d. Other: As noted.

11. Cables:
 - a. Types: As recommended by manufacturer.
 - b. Lengths: As required to accommodate device locations.
 12. Built-in Diagnostic System:
 - a. Features:
 - 1) Field programmable electronics.
 - 2) Self-diagnostics with troubleshooting codes.
 - 3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
 - 4) Initial flow tube calibration and subsequent calibration checks.
 13. Factory Calibration:
 - a. Calibrated in an ISO 9001 and NIST certified factory.
 - b. Factory flow calibration system must be certified by volume or weight certified calibration devices.
 - c. Factory flow calibration system shall be able to maintain calibration flow rate for at least 5 minutes for repeatability point checks.
 14. Factory Ready for Future In situ Verifications: If noted.
 - a. Original meter parameter values available from vendor by request.
 15. Manufacturers:
 - a. Emerson Process Management, Rosemount Division:
 - 1) Model 8705 (flanged) and Model 8711(wafer) flow tubes.
 - 2) Model 8712 (surface) and Model 8732 (integral) transmitters.
 - b. Krohne (includes IFC 020K/IFC 090K (integral) or IFC 020F/IFC 090F (remote) signal converter).
 - 1) Aqua Flux Flowmeter (Size: 3/8 to 120 inches).
 - 2) EnviroMag, IFS 4000 Flowmeter (Size: 2 to 60 inches).
 - 3) IFS 1000 EcoFlux Flowmeter (Size: 1/10 to 8 inches).
 - c. ABB Automation MagMaster (includes Transmitter):
 - 1) 10D1475 Mini-Mag (Size: 1/10 to 4 inches).
 - 2) MFE (Size: 1/2 to 24 inches).
 - 3) Plus MFF (Size: 8 to 84 inches).
- C. F16 Flow Element, Rotameter:
1. General:
 - a. Function: Indicate flow rate.
 - b. Type: Variable area; float and tapered tube.

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2. Service Conditions:
 - a. Process Fluid: Water, unless otherwise noted.
 - b. Temperature Range:
 - 1) Process Fluid: 33 degrees F to 250 degrees F.
 - 2) Ambient: 32 degrees F to 125 degrees F.
 - c. Maximum Operating Pressure: As noted.
3. Performance:
 - a. Flowrate Range: As noted.
 - b. Accuracy: Plus or minus 2 percent of maximum flow, uncalibrated, over 12.5:1 turndown.
 - c. Repeatability: 0.5 percent of full scale.
4. Features:
 - a. Nominal Length: 10 inches.
 - b. Float Material: Type 316 stainless steel.
 - c. Tube: Borosilicate glass.
 - d. Seal:
 - 1) Type: O-ring, unless otherwise noted.
 - 2) Material: Buna-N, unless otherwise noted.
 - e. Polycarbonate operator protection shield.
 - f. Mounting: In line, unless otherwise noted.
 - g. Scales: Direct-reading external metal scale, unless otherwise noted.
 - h. Pressure Drop Design: Standard, unless otherwise noted.
5. Size and Process Connections:
 - a. Connection Size: As noted.
 - b. Tube Size: As noted.
 - c. Connection Material: Type 316 stainless steel, unless otherwise noted.
 - d. Connection Type: Threaded NPT, unless otherwise noted.
 - e. Connection Orientation: Vertical, unless otherwise noted.
6. Signal Interface: None, unless otherwise noted.
7. Manufacturers and Products:
 - a. ABB; Series FGM4500.
 - b. Brooks; Series 1100.

D. P4 Pressure Gauge:

1. General:
 - a. Function: Local pressure indication.
 - b. Type: Bourdon tube element.
2. Performance:
 - a. Scale Range: As noted.
 - b. Accuracy: Plus or minus 0.50 percent of full scale.

3. Features:
 - a. Dial: 4-1/2-inch diameter.
 - b. Pointer Vibration Reduction: Required, unless otherwise noted.
Use the following method.
 - 1) Liquid filled gauge front, unless otherwise noted.
 - a) Glycerine fill, unless otherwise noted.
 - c. Case Material: Black thermoplastic, unless otherwise noted.
 - d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
 - 1) Stainless steel, unless otherwise noted.
 - e. Pointer: Adjustable by removing ring and window.
 - f. Window: Glass or acrylic, unless otherwise noted.
 - g. Threaded reinforced polypropylene front ring.
 - h. Case Type: Solid front with blow-out back.
4. Process Connection:
 - a. Mounting: Lower stem, unless otherwise noted.
 - b. Size: 1/2-inch MNPT, unless otherwise noted.
5. Accessories:
 - a. Throttling Device: Required, unless otherwise noted.
 - 1) Type suitable for the intended service.
 - 2) Install in gauge socket bore.
6. Manufacturers and Products: Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS! “Or-equal” approved.

END OF COMPONENT SPECIFICATIONS

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HOOPER WPP INSTRUMENT AND CONTROL PANEL LIST						
Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Panel No.
303AE/AIT	A41	Analyzer Element and Transmitter, UV Transmittance	Refer to Component Specification	08-N-601		300SCC
303FI	F16	Flow Element, Rotameter	Fluid: Filtered Water Flow Range: 0 – 2 liters/minute Line Size: 1-1/4"	08-N-601		NA
305FE1/FIT1	F4	Flow Element and Transmitter, Electromagnetic	Fluid: Filtered Water Flow Range: 0 – 22 MGD Line Size: 36"	08-N-601	4091-220	305CPP1 (Vendor Panel)
305FE2/FIT2	F4	Flow Element and Transmitter, Electromagnetic	Fluid: Filtered Water Flow Range: 0 – 22 MGD Line Size: 36"	08-N-601	4091-220	305CPP2 (Vendor Panel)
305PI1A	P4	Pressure Gauge	Range: 0 – 30 PISG	08-N-601	4091-304A	
305PI1B	P4	Pressure Gauge	Range: 0 – 30 PISG	08-N-601	4091-304A	
HICKS WPP INSTRUMENT AND CONTROL PANEL LIST						
Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Panel No.
303AE/AIT	A41	Analyzer Element and Transmitter, UV Transmittance	Refer to Component Specification	08-N-601		300SCC
303FI	F16	Flow Element, Rotameter	Fluid: Filtered Water Flow Range: 0 – 2 liters/minute Line Size: 1-1/4"	08-N-602		NA
305FE1/FIT1	F4	Flow Element and Transmitter, Electromagnetic	Fluid: Filtered Water Flow Range: 0 – 10 MGD Line Size: 36"	08-N-602	4091-220	305CPP1 (Vendor Panel)
305FE2/FIT2	F4	Flow Element and Transmitter, Electromagnetic	Fluid: Filtered Water Flow Range: 0 – 10 MGD Line Size: 36"	08-N-602	4091-220	305CPP2 (Vendor Panel)
305PI1A	P4	Pressure Gauge	Range: 0 – 15 PISG	08-N-601	4091-304A	
305PI1B	P4	Pressure Gauge	Range: 0 – 15 PISG	08-N-601	4091-304A	

LOOP SPECIFICATION

Note(s):

1. This document does not describe every function required by the Contract Documents. Rather, it supplements and clarifies the functions required by the P&IDs.
2. The PIC Systems Integrator shall incorporate the new PLCs the new process equipment and functions into the existing plant PLCs and SCADA servers.

OVERVIEW

The PICS System Integrator shall program and configure the following devices:

HMI graphics and SCADA server databases.

ALARMS

The PICS System Integrator shall display on the computer HMI graphics all alarms shown on the P&IDs and I/O List.

The PICS System Integrator shall also display calculated alarms such as Low Level in each Storage Tank. The PIC System Integrator shall program the PLC to calculate these alarms.

The PIC System Integrator shall store all alarms in data registers.

STATUS MONITORING

The PICS System Integrator shall display on the computer HMI graphics all status signals shown on the P&IDs and I/O List. Examples include ON status of each Chlorine Dioxide Generation System.

The PIC System Integrator shall store all status signals in data registers.

ANALOG DISPLAYS

The PICS System Integrator shall display all analog input variables shown on the P&IDs and I/O List. Examples include storage tank levels.

The PIC System Integrator shall store these analog input variables in data registers.

TRENDS

The PIC System Integrator shall create and display trends of all analog inputs and outputs that are part of this project. This includes field analog inputs and software created analog outputs. Create and display additional trends as noted in these Loop Specifications.

MISCELLANEOUS CONTROL STRATEGIES

Preventing Nuisance Alarms

To prevent nuisance alarms, the PLC System Integrator shall provide PLC software time delays to alarm and control strategies during non-steady state conditions such as startup, loss of power and transitions.

REQUIRED GLOBAL FUNCTIONS

1. Calculate and display Elapsed Run Time of each pump or other piece of equipment whose ON status is displayed by the PMCS System.
2. Calculate and display Cycle Counts of each pump or other piece of equipment whose ON status is displayed by the PMCS System.
3. Trend each process variable that has a PLC analog input.
4. If shown under PMCS discrete displays, derive HIGH-HIGH and LOW-LOW alarms from the associated process variable.
5. Totalize flow rate of each flow rate analog input.
6. Bumpless Transfer: For the PLC/PMCS System, configure all “software” Manual/Auto switches so they provide “bumpless transfer.”
 - a. Manual to Auto Transition: Once the transition occurs, immediately run the device if the Auto Mode so commands.
 - b. Auto to Manual Transition:
 - 1) If a device has been running in Auto, configure so it continues to run once placed in Manual.
 - 2) If a device has not been running in Auto, configure so it does not run once placed in Manual.
 - 3) If an adjustable speed device has been running at a certain speed in Auto, configure so it runs at the same speed once placed in Manual.

MODULAR FUNCTIONS (Implement if noted in the specific unit process loop specifications)

Modular Function: Field Alarm

PMCS Display and Control Functions

Field Alarm.

- Display flashing yellow when Field Alarm True and Unacknowledged.
- Display steady yellow when Field Alarm True and Acknowledged.
- Display ceases when Field Alarm False and Acknowledged.

Modular Function: Field Condition Status

PMCS Discrete Display

Field Condition Status (see specific loop to identify specific field condition).

Modular Function: Flow

PMCS Discrete Display

High Flow Alarm.

Low Flow Alarm.

PMCS Value Displays

Flow Rate.

Total Flow, Daily.

Total Flow, Monthly.

PMCS Trends

See Global Functions.

Modular Function: Modulating Valve Operation

PMCS Discrete Displays

Position Fail.

Valve under PMCS control (Field Hand Switch in Remote or Auto).

PMCS Value Display

Position.

W.J. HOOPER WPP AND TERRY R. HICKS WPP –
UV SYSTEM UPGRADES

PMCS Display and Control Functions

Provide MANUAL/OFF/AUTO control of Valve.

- In MANUAL, provide position adjust.
- In AUTO, provide control as per individual Unit Process Loop Specifications.

Modular Function: RUN Status

PMCS Discrete Display

ON Status.

Pump/Equipment Fail.

Pump/Equipment under PMCS Control (Field/MCC/VFD Hand Switch – if provided – in Remote or Auto).

Pump/Equipment Local Disconnect Open (if provided).

PMCS Value Display

Elapsed Run Time; display last 24 hours; see Global Functions.

Cycle Counter; display last 24 hours; see Global Functions.

UNIT PROCESSES

Unit Process 30: UV Disinfection

This process is controlled by the vendor provided control system. However, certain functions must be performed from the plant PLCs and CS workstations. Data exchange requirements and system functionality are specified in Section 46 66 20, Ultraviolet Disinfection Equipment for Drinking Water. The PICS subcontractor must carefully read the functional requirement for the ULTRAVIOLET DISINFECTION EQUIPMENT FOR DRINKING WATER control system and work closely with the supplier to implement the data exchange and SCADA requirements specified herein and shown on the Drawings.

The UV system will be connected to SCADA via Ethernet IP to provide status and monitoring signals to SCADA for display on the HMI.

HICKS WPP:

A new Modulating Control Valve (306FV) will be added in the UV Discharge header at Hick. I/O will be wired to UV Vendor panel 300SCC. However all control of that valve will originate from Plant SCADA.

Modular Function: Modular Valve Operation. UV Discharge Valve 306FV.

MANUAL control only.

END OF LOOP DESCRIPTIONS

JACOBS

INSTRUMENT CALIBRATION SHEET
EXAMPLE - ANALYZER/TRANSMITTER

Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT					
Code: A7			Name: Leeds & Northrup				Number: WDC30715.B2					
Name: pH Element & Analyzer/Transmitter			Model: I2429-3-2-1-7				Name: UOSA AWT PHASE 3					
			Serial #: 11553322									
FUNCTIONS												
Indicate? Y Record? N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N			CONTROL? N					
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D					
	Scale:	1-14	pH units				SWITCH? N					
Transmit/ Convert? Y	Input:	1-14	pH units				Unit Range:					
	Output:	4-20	mA dc				Differential: fixed/adjustable Reset? automatic / manual					
ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS					
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED		Note No.
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
			Indicated	Output	Indicated	Output		(note rising or falling)		(note rising or falling)		
1.0	1.0	4.0	1.0	4.0	1.0	3.9	1.	N.A.		N.A.		
2.3	2.3	5.6	2.2	5.5	2.3	5.6	2.				I.	
7.5	7.5	12.0	7.5	11.9	7.5	12.0	3.					
12.7	12.7	18.4	12.7	18.3	12.6	18.3	4.					
14.0	14.0	20.0	14.0	20.0	14.0	20.0	5.					
							6.					
							7.					
CONTROL MODE SETTINGS:			P: N.A.	I:	D:							
#	NOTES:									Component Calibrated and Ready for Startup		
	1. Need to recheck low pH calibration solutions.									By: J.D. Sewell		
										Date: Jun-6-92		
										Tag No.: AIT-12-6[pH]		

W.J. HOOPER WPP AND TERRY R. HICKS WPP –
UV SYSTEM UPGRADES

JACOBS

I&C VALVE ADJUSTMENT SHEET

Rev.06.05.92

PARTS	Project Name:		Project Number:		
Body	Type:		Mfr:		
	Size:		Model:		
	Line Connection:		Serial #:		
Operator	Type:		Mfr:		
	Action:		Model:		
	Travel:		Serial #:		
Positioner	Input Signal:		Mfr:		
	Action:		Model:		
	Cam:		Serial #:		
Pilot Solenoid	Action:		Mfr:		
	Rating:		Model:		
			Serial #:		
I/P Converter	Input:		Mfr:		
	Output:		Model:		
	Action:		Serial #:		
Position Switch	Settings:		Mfr:		
	Contacts:		Model:		
			Serial #:		
Power Supply	Type:		Air Set Mfr:		
	Potential:		Model:		
			Serial #:		
ADJUSTMENTS	Initial	Date	VERIFICATION	Initial	Date
Air Set			Valve Action		
Positioner			Installation		
Position Switches			Wire Connection		
I/P Converter			Tube Connection		
Actual Speed					
REMARKS:				Valve Ready for Startup	
				By:	
				Date:	
				Tag No.:	

W.J. HOOPER WPP AND TERRY R. HICKS WPP –
UV SYSTEM UPGRADES

JACOBS

I&C VALVE ADJUSTMENT SHEET
EXAMPLE

Rev.06.05.92

PARTS	Project Name: <i>SFO SEWPCP</i>		Project Number: <i>SFO10145.G2</i>		
Body	Type: <i>Vee-Ball</i>		Mfr: <i>Fisher Controls</i>		
	Size: <i>4-inch</i>		Model: <i>1049763-2</i>		
	Line Connection: <i>159 # ANSI Flanges</i>		Serial #: <i>1003220</i>		
Operator	Type: <i>Pneumatic Diaphragm</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Linear - Modulated</i>		Model: <i>4060D</i>		
	Travel: <i>3-inch</i>		Serial #: <i>2007330</i>		
Positioner	Input Signal: <i>3-15 psi</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Direct - air to open</i>		Model: <i>20472T</i>		
	Cam: <i>Equal percentage</i>		Serial #: <i>102010</i>		
Pilot Solenoid	Action:		Mfr:		
	Rating: <i>None</i>		Model:		
			Serial #:		
I/P Converter	Input: <i>4-20 mA dc</i>		Mfr: <i>Taylor</i>		
	Output: <i>3-15 psi</i>		Model: <i>10-T-576-3</i>		
	Action: <i>Direct</i>		Serial #: <i>1057-330</i>		
Position Switch	Settings: <i>Closed / Open 5 deg. rising</i>		Mfr: <i>National Switch</i>		
	Contacts: <i>Close / Close</i>		Model: <i>1049-67-3</i>		
			Serial #: <i>156 & 157</i>		
Power Supply	Type: <i>Pneumatic</i>		Air Set Mfr: <i>Air Products</i>		
	Potential: <i>40 psi</i>		Model: <i>3210D</i>		
			Serial #: <i>1107063</i>		
ADJUSTMENTS	Initial	Date	VERIFICATION	Initial	Date
Air Set	<i>JDS</i>	<i>Jun-06-92</i>	Valve Action	<i>JDS</i>	<i>Jun-03-92</i>
Positioner	<i>JDS</i>	<i>Jun-06-92</i>	Installation	<i>JDS</i>	<i>Jun-03-92</i>
Position Switches	<i>JDS</i>	<i>Jun-06-92</i>	Wire Connection	<i>JDS</i>	<i>Jun-04-92</i>
I/P Converter	<i>JDS</i>	<i>Jun-07-92</i>	Tube Connection	<i>JDS</i>	<i>Jun-04-92</i>
Actual Speed	<i>JDS</i>	<i>Jun-07-92</i>			
REMARKS: <i>Valve was initially installed backwards.</i>				Valve Ready for Startup	
<i>Observed to be correctly installed May-25-92</i>				By: <i>J.D. Sewell</i>	
				Date: <i>Jun-07-92</i>	
				Tag No.: <i>FCV-10-2-1</i>	

EXAMPLE

Project Name: <i>SFO SEWPCP Plant Expansion</i>		Project No.: <i>SFO12345.C1</i>	
Demonstration Test(s): For each functional requirement of the loop:			
(a) List and number the requirement. (b) Briefly describe the demonstration test.			
(c) Cite the results that will verify the required performance. (d) Provide space for signoff.			
<i>1. MEASURE EFFLUENT FLOW</i>			
<i>1.a With no flow, water level over weir should be zero and</i>			
<i>FIT indicator should read zero.</i>			<i>Jun-20-92 BDG</i>
<i>2. FLOW INDICATION AND TRANSMISSION TO LP & CCS</i>			
<i>With flow, water level and FIT indicator should be related by expression</i>			
<i>$Q(\text{MGD}) = 429 * H^{2/3}$ (H = height in inches of water over weir).</i>			
<i>Vary H and observe that following.</i>			
<i>2.a Reading of FIT indicator.</i>			<i>Jun-6-92 BDG</i>
<i>2.b Reading is transmitted to FI on LP-521-1.</i>			<i>Jun-6-92 BDG</i>
<i>2.c Reading is transmitted and displayed to CCS.</i>			<i>Jun-6-92 BDG</i>
<i>H(measured)</i>	<i>0</i>	<i>5</i>	<i>10 15</i>
<i>Q(computed)</i>	<i>0</i>	<i>47.96</i>	<i>135.7 251.7</i>
<i>Q(FIT indicator)</i>	<i>0</i>	<i>48.1</i>	<i>137 253</i>
<i>Q(LI on LP-521-1)</i>	<i>0</i>	<i>48.2</i>	<i>138 254</i>
<i>Q(display by CCS)</i>	<i>0</i>	<i>48.1</i>	<i>136.2 252.4</i>
Forms/Sheets Verified			
By	Date	Loop Accepted By Owner	
Loop Status Report	<i>J.D. Sewell</i>	<i>May-18-92</i>	By: <i>J.D. Smith</i>
Instrument Calibration Sheet	<i>J.D. Sewell</i>	<i>May-18-92</i>	Date: <i>Jun-6-92</i>
I&C Valve Calibration Sheet	<i>N.A.</i>		
Performance Acceptance Test			
By	Date		
Performed	<i>J. Blow MPSDC Co.</i>	<i>Jun-6-92</i>	
Witnessed	<i>B. deGlanville</i>	<i>Jun-6-92</i>	Loop No.: <i>30-12</i>

PROJECT:

Contractor:

Signed by:

AS-BUILT FIBER OPTIC CABLE INSTALLATION

Sheet 1 of 2

Cable Identification:

Routing: From: _____ In: _____
(Identify field panel, control room, etc. in building)

Through: 1
(Identify access hole, building, gallery, etc.)

Through: 2 _____ Through: 5 _____
Through: 3 _____ Through: 6 _____
Through: 4 _____ Through: 7 _____
To: _____ In: _____

See As-Built Conduit/Innerduct Installation forms for identification of conduits/innerducts cable is routed through.

Acceptable Attenuation:
Multimode Fibers

	cable length*			
850 nm:	3.5 dB/km x	km + 1.5 dB =		dB
1300 nm:	1.0 dB/km x	km + 1.5 dB =		dB

*Contractor to provide actual length installed, within ±0.1 km.

Fiber ID	Use/Spare	Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
		850 nm	1,300 nm	850 nm	1,300 nm

Single-mode Fibers

cable length*

1310 nm: 1.0 dB/km x km + 1.5 dB = dB
 1550 nm: 1.0 dB/km x km + 1.5 dB = dB

*Contractor to provide actual length installed, within ±0.1 km.

Fiber ID	Use/Spare	Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
		1,310 nm	1,550 nm	1,310 nm	1,550 nm

Customer: Clayton Co. Water Authority
 Project: WJ Hooper WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hooper Only)



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
-----	----------	-------------

SECTION 40 90 01 - INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

MR Systems understands the requirements of this section and will comply as required and outlined in this scope of work.

1.04 - Submittals
 Action Submittals

NOTE: MR Systems has NOT INCLUDED loop diagrams as this is not required by the Owner.
 Informational Submittals

1.05 - Quality Assurance
 Coordination Meetings - Minimum of one (1)

2.07 - Spare Parts
 MR Systems has EXCLUDED spare parts. DC Power Supplies, Fuses, Indicating Light Bulbs, Relays, Terminal Blocks, and Hand Switches are not required as part of our scope of supply.

2.10 - Source Quality Control
 In-House testing is EXCLUDED. MR Systems will make modifications to existing panels in the field as required and coordinate with the UV Supplier for I/O checkout of their system to the HMI.

3.03 - Fiber Optic Cable Installation
 MR Systems has EXCLUDED Fiber Optics Cable installation. MR Systems will supply fiber cable, connectors, terminations, and testing. Fiber will be installed by OTHERS.

3.04 - Field Quality Control Fiber Optic Cable
 MR Systems will perform testing as required for new fiber optic cabling.

3.06 - Field Quality Control
 Startup and Testing Team
 Operational Readiness Inspections and Calibrations
 Performance Acceptance Tests

3.07 - Training
 Operations and Maintenance Training
 Operations Training
 Maintenance Training

PANEL LIST

Hooper WPP CP-A Admin Building Panel (existing) Panel Modifications

Reuse Fiber Optic Connector Housing/Panel and Fiber/Ethernet Switch

NOTE:

Vendor supplied Hooper WPP 300SC Panel shall have a Fiber Optic Connector Housing/Panel to accept the new 6-strand fiber. MR Systems has NOT INCLUDED any materials within Hooper WPP 300SC.

Customer: Clayton Co. Water Authority
 Project: WJ Hooper WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hooper Only)



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
-----	----------	-------------

LOOP SPECIFICATIONS

MR Systems will modify the existing HMI to accommodate new equipment and controls that are being added as part of this project.

Unit Process 30: UV Disinfection
 Hooper WPP UV Disinfection System

INSTRUMENT LIST

MR Systems will provide the following instruments listed below as they appear on the P&IDs.

08-N-601 - HOOPER WPP PROCESS AND INSTRUMENTATION DIAGRAM

1	FI-303	Rotameter Flow Element Make/Model: ABB VA Master 10A455 Series Service: Hooper WPP Transfer Pump Flow Accessories: Nametag, Stainless Steel
1	FE/FIT-305-1	Electromagnetic Flow Element and Transmitter Make/Model: Rosemount 8750W Series Service: Hooper WPP UV Reactor 1 Flow Line Size: 36" Accessories: Nametag, Stainless Steel
1		Surge Arrestor
1	FE/FIT-305-2	Electromagnetic Flow Element and Transmitter Make/Model: Rosemount 8750W Series Service: Hooper WPP UV Reactor 2 Flow Line Size: 36" Accessories: Nametag, Stainless Steel
1		Surge Arrestor
1	PI-305-1A	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hooper WPP UV Reactor 1 Inlet Pressure Accessories: Nametag, Stainless Steel
1		Ball Valve
1	PI-305-1B	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hooper WPP UV Reactor 1 Outlet Pressure Accessories: Nametag, Stainless Steel
1		Ball Valve

Customer: Clayton Co. Water Authority
 Project: WJ Hooper WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hooper Only)



June 8, 2022

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Bill of Materials and Labor

Qty	Tag/Loop	Description
1	PI-305-2A	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hooper WPP UV Reactor 2 Inlet Pressure Accessories:
1		Nametag, Stainless Steel
1		Ball Valve
1	PI-305-2B	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hooper WPP UV Reactor 2 Outlet Pressure Accessories:
1		Nametag, Stainless Steel
1		Ball Valve

SECTION 40 95 80 - FIBER OPTIC COMMUNICATION SYSTEM

MR Systems understands the requirements of this section and will comply as required and outlined in this scope of work.

1.04 - Submittals

Action Submittals

Informational Submittals

2.01 - Fiber Optic Cable

FROM: Hooper CP-A Admin Building Panel (existing)

TO: 300SCC - Hooper WPP UV System Master Panel

400 Fiber Type: Corning FREEDM ONE, 62.5um Multimode (OM1), 6 Fiber
 12 Connectors: Corning UniCam ST, 62.5um, OM1, Ceramic Ferrule

3.02 - Installation

MR Systems has EXCLUDED Fiber Optics Cable installation. MR Systems will supply fiber cable, connectors, terminations, and testing. Fiber will be installed by OTHERS.

3.04 - Field Quality Control

MR Systems will perform testing as required for new fiber optic cabling.

3.05 - Training

MR Systems has NOT INCLUDED fiber training.

EXCLUSIONS & CLARIFICATIONS

- 1) MR Systems has NOT INCLUDED CAT6 cable, terminations, or testing. This shall be by OTHERS.



Customer: Clayton Co. Water Authority
 Project: WJ Hooper WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hooper Only)



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Bill of Materials and Labor

Qty	Tag/Loop	Description
		Project Labor
One Lot		Project Engineering, Electrical Design, Mechanical Design, Drafting & Administrative Labor (including Travel & Living expenses) to perform final system design and to prepare Submittals and Record Drawings as required by the Contract Documents.
One Lot		HMI Software Applications Development & Graphics Design Labor (including Travel & Living expenses) as required by the Contract Documents.
One Lot		PLC Control Strategy Design & Programming Labor (including Travel & Living expenses) to be performed as required by the Contract Documents.
One Lot		Field Service (including Travel & Living expenses) to provide installation supervision calibrations, startup, training, etc. as required by the Contract Documents.
N/A		Electrical Installation or Terminations (including Travel & Living expenses) to provide installation of conduit, wire, etc. as required by the Contract Documents.
1 Year		Onsite Comprehensive Warranty (including Travel & Living expenses)
One Lot		Freight

Subtotal of Labor and Materials: \$113,276

State Sales Tax is INCLUDED. Assumed sales tax rate is: 8%, Included Sales Tax: \$7,730

Total Project Cost: \$121,006

General Notes:

- A *** Sales Representation ***
 Sothorn Khel, P.E., of MR Systems is our local Sales Engineer. Sothorn may be reached at 678-325-2824 (Office) or 770-519-0597 (Cell).
- B *** Technical Questions ***
 For technical or scope of supply questions contact Sothorn Khel, P.E., of MR Systems. Sothorn may be reached at 678-325-2824 (Office) or 770-519-0597 (Cell).
- C *** Installation of Conduit and Wire ***
 This quotation **DOES NOT INCLUDE** the supply or physical installation of conduit or wire unless specifically noted above.
- D *** Equipment Installation ***
 This quotation **DOES NOT INCLUDE** physical installation of field instruments, pipe, tubing, fittings, isolation valves, instrument stands, instrument mounts, control panels, antennas, masts, wooden poles, or other devices or other equipment unless specifically noted above.

Customer: Clayton Co. Water Authority
 Project: TR Hicks WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hicks Only)



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
-----	----------	-------------

SECTION 40 90 01 - INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

MR Systems understands the requirements of this section and will comply as required and outlined in this scope of work.

1.04 - Submittals
 Action Submittals

NOTE: MR Systems has NOT INCLUDED loop diagrams as this is not required by the Owner.
 Informational Submittals

1.05 - Quality Assurance
 Coordination Meetings - Minimum of one (1)

2.07 - Spare Parts
 MR Systems has EXCLUDED spare parts. DC Power Supplies, Fuses, Indicating Light Bulbs, Relays, Terminal Blocks, and Hand Switches are not required as part of our scope of supply.

2.10 - Source Quality Control
 In-House testing is EXCLUDED. MR Systems will make modifications to existing panels in the field as required and coordinate with the UV Supplier for I/O checkout of their system to the HMI.

3.03 - Fiber Optic Cable Installation
 MR Systems has EXCLUDED Fiber Optics Cable installation. MR Systems will supply fiber cable, connectors, terminations, and testing. Fiber will be installed by OTHERS.

3.04 - Field Quality Control Fiber Optic Cable
 MR Systems will perform testing as required for new fiber optic cabling.

3.06 - Field Quality Control
 Startup and Testing Team
 Operational Readiness Inspections and Calibrations
 Performance Acceptance Tests

3.07 - Training
 Operations and Maintenance Training
 Operations Training
 Maintenance Training

PANEL LIST

Hicks WPP Transfer Pump Station Panel (existing) Panel Modifications

Reuse Fiber Optic Connector Housing/Panel and Fiber/Ethernet Switch

NOTE:

Vendor supplied Hicks WPP 300SC Panel shall have a Fiber Optic Connector Housing/Panel to accept the new 6-strand fiber. MR Systems has NOT INCLUDED any materials within Hicks WPP 300SC.

Customer: Clayton Co. Water Authority
 Project: TR Hicks WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hicks Only)



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
-----	----------	-------------

LOOP SPECIFICATIONS

MR Systems will modify the existing HMI to accommodate new equipment and controls that are being added as part of this project.

Unit Process 30: UV Disinfection
 Hicks WPP UV Disinfection System

INSTRUMENT LIST

MR Systems will provide the following instruments listed below as they appear on the P&IDs.

08-N-602 - HICKS WPP PROCESS AND INSTRUMENTATION DIAGRAM

1	FI-303	Rotameter Flow Element Make/Model: ABB VA Master 10A455 Series Service: Hicks WPP Transfer Pump Flow Accessories: Nametag, Stainless Steel
1	FE/FIT-305-1	Electromagnetic Flow Element and Transmitter Make/Model: Rosemount 8750W Series Service: Hicks WPP UV Reactor 1 Flow Line Size: 36" Accessories: Nametag, Stainless Steel
1		Surge Arrestor
1	FE/FIT-305-2	Electromagnetic Flow Element and Transmitter Make/Model: Rosemount 8750W Series Service: Hicks WPP UV Reactor 2 Flow Line Size: 36" Accessories: Nametag, Stainless Steel
1		Surge Arrestor
1	PI-305-1A	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hicks WPP UV Reactor 1 Inlet Pressure Accessories: Nametag, Stainless Steel
1		Ball Valve
1	PI-305-1B	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hicks WPP UV Reactor 1 Outlet Pressure Accessories: Nametag, Stainless Steel
1		Ball Valve



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
1	PI-305-2A	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hicks WPP UV Reactor 2 Inlet Pressure Accessories:
1		Nametag, Stainless Steel
1		Ball Valve
1	PI-305-2B	Pressure Gauge with Ball Valve Make/Model: Ashcroft 1279 Series Service: Hicks WPP UV Reactor 2 Outlet Pressure Accessories:
1		Nametag, Stainless Steel
1		Ball Valve

SECTION 40 95 80 - FIBER OPTIC COMMUNICATION SYSTEM

MR Systems understands the requirements of this section and will comply as required and outlined in this scope of work.

1.04 - Submittals

- Action Submittals
- Informational Submittals

2.01 - Fiber Optic Cable

FROM: Hicks WPP Transfer Pump Station Panel (existing)
 TO: 300SCC - Hicks WPP UV System Master Panel
 Fiber Type: Corning FREEDM ONE, 62.5um Multimode (OM1), 6 Fiber
 Connectors: Corning UniCam ST, 62.5um, OM1, Ceramic Ferrule

500
12

3.02 - Installation

MR Systems has EXCLUDED Fiber Optics Cable installation. MR Systems will supply fiber cable, connectors, terminations, and testing. Fiber will be installed by OTHERS.

3.04 - Field Quality Control

MR Systems will perform testing as required for new fiber optic cabling.

3.05 - Training

MR Systems has NOT INCLUDED fiber training.

EXCLUSIONS & CLARIFICATIONS

- 1) MR Systems has NOT INCLUDED CAT6 cable, terminations, or testing. This shall be by OTHERS.



Customer: Clayton Co. Water Authority
 Project: TR Hicks WPP UV System Upgrades
 MR Quote #: Q22-9855, Rev. 1 (Hicks Only)



June 8, 2022

Quote Expiration

December 31, 2022

Bill of Materials and Labor

Qty	Tag/Loop	Description
Project Labor		
One Lot		Project Engineering, Electrical Design, Mechanical Design, Drafting & Administrative Labor (including Travel & Living expenses) to perform final system design and to prepare Submittals and Record Drawings as required by the Contract Documents.
One Lot		HMI Software Applications Development & Graphics Design Labor (including Travel & Living expenses) as required by the Contract Documents.
One Lot		PLC Control Strategy Design & Programming Labor (including Travel & Living expenses) to be performed as required by the Contract Documents.
One Lot		Field Service (including Travel & Living expenses) to provide installation supervision calibrations, startup, training, etc. as required by the Contract Documents.
N/A		Electrical Installation or Terminations (including Travel & Living expenses) to provide installation of conduit, wire, etc. as required by the Contract Documents.
1 Year		Onsite Comprehensive Warranty (including Travel & Living expenses)
One Lot		Freight

Subtotal of Labor and Materials: \$113,411

State Sales Tax is INCLUDED. Assumed sales tax rate is: 8%, Included Sales Tax: \$7,741

Total Project Cost: \$121,152

General Notes:

- A *** Sales Representation ***
 Sothorn Khel, P.E., of MR Systems is our local Sales Engineer. Sothorn may be reached at 678-325-2824 (Office) or 770-519-0597 (Cell).

- B *** Technical Questions ***
 For technical or scope of supply questions contact Sothorn Khel, P.E., of MR Systems. Sothorn may be reached at 678-325-2824 (Office) or 770-519-0597 (Cell).

- C *** Installation of Conduit and Wire ***
 This quotation **DOES NOT INCLUDE** the supply or physical installation of conduit or wire unless specifically noted above.

SECTION 40 99 90
PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Instrumentation, Systems, Automation Society (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
 2. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
 - c. ICS 2, Industrial Control Devices, Controllers and Assemblies.
 3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 4. UL: 508A, Standards for Safety, Industrial Control Panels.

1.02 SYSTEM DESCRIPTION

- A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer's factories.
- B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

1.03 SUBMITTALS

- A. Action Submittals:
1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
 2. Catalog information on electrical devices furnished with system.
 3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
 4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
 5. Plumbing diagrams of preplumbed panels and interconnecting plumbing diagrams.
 6. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.

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B. Informational Submittals:

1. Programmable Controller Submittals:
 - a. Complete set of user manuals.
 - b. Fully documented ladder logic listings.
 - c. Function listing for function blocks not fully documented by ladder logic listings.
 - d. Cross-reference listing.
2. Manufacturer's list of proposed spares, expendables, and test equipment.
3. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

1.05 EXTRA MATERIALS

A. Spares, Expendables, and Test Equipment:

1. Selector Switch, Pushbutton, and Indicating Light: 20 percent, one minimum, of each type used.
2. Light Bulb: 100 percent, 2 minimum, of each type used.
3. Fuse: 100 percent, 5 minimum, of each type used.
4. Surge Suppressors: 20 percent, one minimum, of each type used.

PART 2 PRODUCTS

2.01 GENERAL

- A. Section 40 90 01, Instrumentation and Control for Process Systems.

2.02 SIGNAL CHARACTERISTICS

- A. As defined in Section 40 90 01, Instrumentation and Control for Process Systems.

2.03 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering; Model A-HCI.

2.04 CONTROL PANEL

- A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.
- B. Conform to NEMA ratings as specified in individual equipment sections.
- C. Minimum Metal Thickness: 14-gauge.
- D. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.
- E. Doors:
 - 1. Three-point latching mechanisms in accordance with NEMA 250 Type 1 and 12 panels with doors higher than 18 inches.
 - 2. For other doors, stainless steel quick release clamps.
- F. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.
- G. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.
- H. Temperature Control:
 - 1. Provide Heat Load Calculations for all control panels.
 - 2. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
 - 3. Furnish cooling fans with air filters if required to dissipate heat.
 - 4. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel or in panel face.
 - 5. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.
- I. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.
- J. Lighting: Minimum of one door switch controlled internal LED light for panels 12 cubic feet and larger.
- K. Minimum of one 120-volt GFCI duplex receptacle for panels 12 cubic feet and larger.

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- L. Finish:
 - 1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.
 - 2. Internal Surfaces (Excluding Aluminum and Stainless Steel): White enamel.
- M. Panel Manufacturers:
 - 1. Hoffman.
 - 2. H.F. Cox.
- N. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels.
 - 1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

2.05 CONTROL PANEL ELECTRICAL

- A. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.
- B. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.
- C. Control Panels without Motor Starters:
 - 1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
 - 2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.
 - 3. Circuit Breakers:
 - a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
 - b. Branch Circuit Breakers: 15 amps at 250V ac.
 - c. Breaker Manufacturers and Products:
 - 1) Heineman Electric Co.; Series AM.
 - 2) Airpax/North American Philips Controls Corp.; Series 205.
- D. Control Panels with Three-Phase Power Supplies and Motor Starters:
 - 1. Interlock main circuit breaker with panel door.
 - a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
 - b. Mount operator controls and indications on front access door.

2. Circuit Breakers:
 - a. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.
 - b. 65,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified in package system equipment specification sections.
 - c. Tripping: Indicate with operator handle position.
3. Magnetic Motor Starters:
 - a. Full voltage, NEMA ICS 2, Class A, Size O minimum.
 - b. Include three-pole bimetallic or eutectic alloy thermal overload relays sized for each motor.
 - c. Manual reset type with reset button mounted on panel door.
4. Motor Control: 120V ac (except intrinsically safe circuits where applicable).
 - a. Power Control Transformer:
 - 1) Sufficient capacity to serve connected load, including 200VA for duplex outlet plus 100VA (minimum).
 - 2) Limit voltage variation to 15 percent during contact pickup.
 - 3) Fuse one side of secondary winding and ground the other.
 - 4) Furnish primary winding fuses in ungrounded conductors.
5. Power Monitoring Relay:
 - a. Protect three-phase equipment from single phasing, phase imbalance, or phase reversal.
 - b. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.
 - c. Transient Voltage Protection: 10,000 volts.
 - d. Manufacturer and Product: Furnas; Class 47.
6. Power Distribution Blocks: Furnish to parallel feed tap on branch circuit protective devices. Do not “leap frog” power conductors.
7. Terminations for Power Conductors: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Wiring:

1. ac Circuits:
 - a. Type: 600-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than 14 AWG.
2. Analog Signal Circuits:
 - a. Type: 300-volt, Type 2 stranded copper, twisted shielded pairs.
 - b. Size: 18 AWG, minimum.
3. Other dc Circuits.
 - a. Type: 600-volt, Type MTW stranded copper.
 - b. Size: 18 AWG, minimum.

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4. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.
 5. Enclose wiring in sheet metal raceways or plastic wiring ducts.
 6. Wire Identification: Numbered and tagged at each termination.
 - a. Wire Tags: Machine printed, heat shrink.
 - b. Manufacturers:
 - 1) Brady PermaSleeve.
 - 2) Tyco Electronics.
- F. Wiring Interface:
1. For analog and discrete signal, terminate at numbered terminal blocks.
 2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
 3. For panel, terminate at equipment on/with which it is mounted.
- G. Terminal Blocks:
1. Quantity:
 - a. For external connections.
 - b. Wire spare or unused panel mounted elements to their panels' terminal blocks.
 - c. Spare Terminals: 20 percent of connected terminals, but not less than 10.
 2. General: Group to keep 120V ac circuits separate from 24V dc circuits.
 - a. Connection Type: Screw connection clamp.
 - b. Compression Clamp:
 - 1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
 - 2) Guides strands of wire into terminal.
 - c. Screws: Hardened steel, captive, and self-locking.
 - d. Current Bar: Copper or treated brass.
 - e. Insulation:
 - 1) Thermoplastic rated for minus 55 to plus 110 degrees C.
 - 2) Two funnel shaped inputs to facilitate wire entry.
 - f. Mounting:
 - 1) Rail.
 - 2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - 3) End Stops: One at each end of rail, minimum.
 - g. Wire Preparation: Stripping only.
 - h. Jumpers: Allow jumper installation without loss of space on terminal or rail.

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- i. Marking System:
 - 1) Terminal number shown on both sides of terminal block.
 - 2) Allow use of preprinted and field marked tags.
 - 3) Terminal strip numbers shown on end stops.
 - 4) Mark terminal block and terminal strip numbers as shown.
3. Terminal Block, 120-Volt Power:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 30 amp.
 - c. Wire Size: 22 through 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Gray body.
 - f. Spacing: 0.25 inch, maximum.
 - g. Manufacturer and Product: Entrelec; Type M4/6.
4. Terminal Block, Ground:
 - a. Wire Size: 22 through 12 AWG.
 - b. Rated Wire Size: 12 AWG.
 - c. Color: Green and yellow body.
 - d. Spacing: 0.25 inch, maximum.
 - e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
 - f. Manufacturer and Product: Entrelec; Type M4/6.P.
5. Terminal Block, Blade Disconnect Switch:
 - a. Use: Provide one for each discrete input and output field interface wire.
 - b. Rated Voltage: 600V ac.
 - c. Rated Current: 10 amp.
 - d. Wire Size: 22 through 12 AWG.
 - e. Rated Wire Size: 12 AWG.
 - f. Color: Gray body, orange switch.
 - g. Spacing: 0.25 inch, maximum.
 - h. Manufacturer and Product: Entrelec; Type M4/6.SN.
6. Terminal Block, Fused, 24V dc:
 - a. Rated Voltage: 600V dc.
 - b. Rated Current: 6.3 amp.
 - c. Wire Size: 22 through 12 AWG.
 - d. Rated Wire Size: 12 AWG.
 - e. Color: Gray body.
 - f. Fuse: 5 by 20 GMA fuses.
 - g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
 - h. Indication: LED diode 24V dc.
 - i. Leakage Current: 5.2 mA, maximum.
 - j. Spacing: 0.32 inch, maximum.
 - k. Manufacturer and Product: Entrelec; Type M4/6.SFD.

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7. Terminal Block, Fused, 120V ac:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 6.3 amp.
 - c. Wire Size: 22 through 12 AWG
 - d. Rated Wire Size: 12 AWG.
 - e. Color: Gray body.
 - f. Fuse: 5 by 20 GMA fuses.
 - g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
 - h. Indication: Neon lamp 110V ac.
 - i. Leakage Current: 1.8 mA, maximum.
 - j. Spacing: 0.32 inch, maximum
 - k. Manufacturer and Product: Entrelec; Type M4/6.SFL.

- H. Grounding: Internal copper grounding bus for ground connections on panels, consoles, racks, and cabinets.

- I. Relays:
 1. General:
 - a. Relay Mounting: Plug-in type socket.
 - b. Relay Enclosure: Provide dust cover.
 - c. Socket Type: Screw terminal interface with wiring.
 - d. Socket Mounting: Rail.
 - e. Furnish holddown clips.
 2. Control Circuit Switching Relay, Nonlatching:
 - a. Type: Compact general purpose plug-in.
 - b. Contact Arrangement: 3 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 240V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Push-to-test button.
 - k. Manufacturer and Product: Potter and Brumfield; Series KUP.
 3. Control Circuit Switching Relay, Latching:
 - a. Type: Dual coil mechanical latching relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 120V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 2.7 watts (dc), 5.3VA (ac).

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- g. Expected Mechanical Life: 500,000 operations.
- h. Expected Electrical Life at Rated Load: 50,000 operations.
- i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
- 4. Control Circuit Switching Relay, Time Delay:
 - a. Type: Adjustable time delay relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 240V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As specified or shown.
 - f. Operating Temperature: Minus 10 to 55 degrees C.
 - g. Repeatability: Plus or minus 2 percent.
 - h. Delay Time Range: Select range such that time delay set point fall between 20 to 80 percent or range.
 - i. Time Delay Set Point: As specified or shown.
 - j. Mode of Operation: As specified or shown.
 - k. Adjustment Type: Integral potentiometer with knob external to dust cover.
 - l. Manufacturer and Products: Potter and Brumfield.
 - 1) Series CB for 0.1-second to 100-minute delay time ranges.
 - 2) Series CK for 0.1- to 120-second delay time ranges.
- J. Intrinsic Safety Barriers:
 - 1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
 - a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
 - 2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
 - a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
- K. Programmable Controllers: As specified in individual equipment sections.
- L. Front-of-Panel Devices in Conjunction with NEMA 250, Type 1 and 12 Panels:
 - 1. Potentiometer Units:
 - a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
 - b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
 - c. Include legend plates with service markings.
 - d. Manufacturers and Products:
 - 1) Allen-Bradley; Model 800T.
 - 2) Eaton/Cutler-Hammer; Model 10250T.

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2. Indicating Lights:
 - a. Heavy-duty, push-to-test type, oiltight, industrial type with integral transformer for 120V ac applications.
 - b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
 - c. Manufacturers and Products:
 - 1) Eaton/Cutler-Hammer; Type 10250T.
 - 2) General Electric; CR2940U.
 3. Pushbutton, Momentary:
 - a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
 - b. Standard size legend plates with black field and white markings for service legend.
 - c. Manufacturers and Products:
 - 1) Square D; Class 9001, Type K.
 - 2) Eaton/Cutler-Hammer; Type T.
 - 3) General Electric; Type CR-2940.
 4. Selector Switch:
 - a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.
 - b. Standard size, black field, legend plates with white markings, for service legend.
 - c. Operators: Black knob type.
 - d. Single-hole mounting, accommodating panel thicknesses from 1/16 inch to 1/4 inch.
 - e. Manufacturers and Products for Units with up to Four Selection Positions:
 - 1) Eaton/Cutler-Hammer; Type T.
 - 2) Square D; Type K.
 - f. Manufacturers and Products for Units with up to 12 Selection Positions:
 - 1) Rundel-Iddec; Standard Cam Switch.
 - 2) Electros witch; 31.
- M. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:
1. Potentiometer, Watertight:
 - a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
 - b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.

- c. Include engraved legend plates with service markings.
- d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.
- 2. Indicating Lights, Watertight:
 - a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with integral transformer for 120V ac applications and corrosion-resistant service.
 - b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
 - c. Manufacturers and Products:
 - 1) Square D; Type SK.
 - 2) Allen-Bradley; Type 800H.
- 3. Pushbutton, Momentary, Watertight:
 - a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
 - b. Standard size, black field, legend plates with white markings for service legend.
 - c. Manufacturers and Products:
 - 1) Square D; Type SK.
 - 2) Allen-Bradley; Type 800H.
- 4. Selector Switch, Watertight:
 - a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
 - b. Standard size, black field, legend plates with white markings, for service legend.
 - c. Operators: Black knob type.
 - d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
 - e. Manufacturer and Products:
 - 1) Square D; Class 9001, Type SK.
 - 2) Allen-Bradley; Type 800H.

2.06 HARDWARE DOCUMENTATION

- A. Provide the following for all elements of the PLC:
 - 1. Block Diagram: A diagram showing all major system components. Identify components by manufacturer and model number. Show interconnecting cables diagrammatically.
 - 2. Bill-of-Materials: A list of all PLC components. Group components by type and include:
 - a. Component manufacturer, model number and part number.
 - b. Component description.

- c. Quantity supplied.
- d. Reference to component catalog information.
3. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all elements of the PLC system. Clearly mark all options and features proposed for this Project.
4. Interconnecting Wiring Diagrams: Diagrams shall show all PLC elements, their interconnecting cables and wiring terminations, and all terminations to all interacting elements and subsystems. Terminations shall be numbered. Terminations for circuits extending outside PLC assemblies and/or leaving panels shall be labeled with circuit names corresponding to the Circuit and Raceway Schedule. The external circuit portion of this diagram shall be coordinated with the Electrical Subcontractor and shall bear his mark showing that this work has been done.
5. Outline Drawings: Equipment envelope drawings showing: External dimensions, enclosure materials, conduit connections and installation requirements.
6. Installation Details: Any modifications or further details as may be required to supplement the Contact Documents and adequately define the installation of the PLC elements.
7. Input/Output List: For each I/O point, list point type, tag number of the source or final control element, equipment description, PLC number, PLC terminal identification, rack number, module slot number and PLC address.
8. Provide documentation on the type of Operator Interface being used.

2.07 INSTRUMENT TAG NUMBERS

- A. Tag numbers shall match those shown on P&IDs.

2.08 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

- A. Nametags: Permanently mounted bearing entire ISA tag number.
 1. Panel Mounted: Plastic, mounted to instrument behind panel face.
 2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attached with stainless steel.
- B. Service Legends (Integrally Mounted with Instrument) and Nameplates:
 1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.

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2. Color: White with black letters.
3. Letter Height: 3/16 inch.
4. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2-inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	Inscription(s)	Color
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

D. Standard Pushbutton Colors and Inscriptions:

1. Use following unless otherwise noted in:

Tag Function	Inscription(s)	Color
OO	ON OFF	Red Green
OC	OPEN CLOSE	Red Green
OOR	ON OFF REMOTE	Red Green White

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Tag Function	Inscription(s)	Color
SS	START STOP	Red Green
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

2.09 ELECTRICAL SURGE AND TRANSIENT PROTECTION

- A. General: Equip control panels with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.
- B. Suppressor Locations:
 - 1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).
 - 2. On analog pairs at each end when the pair travels outside of building.
 - 3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.
- C. Power Supply Suppressor Assemblies:
 - 1. Suitable for connection to 120-volt, single-phase power supplies EDCO “HSP SERIES.”
 - 2. Suitable for connection to 480-volt, three-phase power supplies; Square D J9200-9A.
- D. Analog Signal Cable Suppressor Assemblies:
 - 1. Epoxy encapsulated within a phenolic enclosure.
 - 2. Flame retardant.
 - 3. Four lead devices; include a threaded mounting/grounding stud.
 - 4. Manufacturer and Product: EDCO; SRA-64 Series.
- E. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation as specified in Division 26, Electrical, and suppressor manufacturer’s requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

PART 3 EXECUTION

3.01 FACTORY TEST

- A. Submit a test for the Contractor's approval. Approval of the test plan is a prerequisite to actual factory test.
- B. Test all non loop-specific functions including, but not limited to, the following:
 - 1. Failure Mode and Backup Procedures: Power failure, redundant operation, auto restart, disk backup and reload, retentive outputs.
 - 2. Communication with PLC programmer.
 - 3. Man-Machine Interface: Operation of PLC with the specified industrially hardened operator interface.
 - 4. Programming and documentation methods and features.
- C. Test and debug all application programs to prove that each system works as specified.
- D. Test shall be unwitnessed.

3.02 OWNER TRAINING

- A. Provide a minimum of 2-days of training at the jobsite for the Owner's personnel in the operation of the PLC and for onsite hardware training for the Owner's instrument technicians in the maintenance of the OI and PLC hardware.
- B. Operations:
 - 1. Training shall include:
 - a. Standard operational features of system equipment provided.
 - b. Specific Features Provided for this Project Including:
 - 1) Loop functions.
 - 2) Operation of Each Loop: For example, AUTO/MANUAL control, control set point settings, control mode selection, alarm acknowledgment, use of operator interface.
 - 3) Interfaces with other loops and subsystems.
- C. Hardware Maintenance:
 - 1. Training shall Include:
 - a. Standard hardware features of the PLC and operator interface.
 - b. Specific training for the actual hardware configuration provided.

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- c. Test, adjustment, and calibration procedures.
- d. Troubleshooting, component removal and replacement, and periodic maintenance.

3.03 O&M MANUALS

A. Hardware:

- 1. Provide the Following:
 - a. Updated versions of all material described under Paragraph Hardware Documentation.
 - b. Component Manufacturers' O&M Manuals: Include manuals to cover installation, operation, maintenance, troubleshooting, and calibration.
 - c. List of spare parts and expendables provided and list of spare parts recommended.

B. Software:

- 1. Provide the Following:
 - a. Programming Manuals: Component manufacturers' standard programming manuals.
 - b. Software Documentation: Provide a final version of the material called for under Paragraph Software Design Submittal.

3.04 ELECTRICAL POWER AND SIGNAL WIRING

- A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.
- B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.
- C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.
- D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.05 PROTECTION

- A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.
- B. During Work, periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules at Substantial Completion.

END OF SECTION

SECTION 46 66 20
ULTRAVIOLET DISINFECTION EQUIPMENT FOR DRINKING WATER

PART 1 GENERAL

1.01 SUMMARY

- A. The Work of this section includes design, fabrication, factory testing, delivery, installation, and onsite services during construction and commissioning of a pressurized vessel ultraviolet (UV) disinfection system complete with accessories necessary for an operating system.
- B. Unit Responsibility: The Work requires UV disinfection system, complete with accessories and control equipment, be end product of one responsible system supplier. Supplier shall furnish components and accessories of the system to enhance compatibility, ease of operation and maintenance, and to place equipment in operation in conformance with performance, features, and functions specified.
- C. UV Supplier Scope of Supply:
 - 1. Furnish UV disinfection system complete with:
 - a. Validated UV reactors.
 - b. UV reactor power/control cabinets.
 - c. Power cables between the power panels and the reactors
 - d. Power supply line filters, if required.
 - e. Transient voltage surge suppressors, if required.
 - f. Lamp power ballasts.
 - g. Power supply transformers, if required.
 - h. UV Lamps.
 - i. Quartz sleeves.
 - j. Calibrated duty and reference UV sensors.
 - k. Air relief valves on the UV reactor.
 - l. Automatic cleaning system or Hydraulic System Center (HSC)
 - m. Electrical and control wiring within UV reactor (as shown on Contract Drawings).
 - n. UV reactor temperature for a complete and operable UV System.
 - o. Extra materials.
 - p. Shipping components to Site.
 - 2. UV supplier shall provide factory testing, installation assistance, functional testing, and performance testing as defined herein:
 - a. Coordination with Installing Contractor to ensure UV equipment and piping arrangement meets minimum requirements for UV hydraulics, equipment access, and bracing.

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- b. Assistance during product installation to include observation, guidance, instruction of Installing Contractor's assembly, erection, installation, or application procedures.
 - c. Completion of field wiring inside UV control panels to facilitate delivery and installation of panels in sub-pieces.
 - d. Inspection, checking, and adjustment as required for the product to function as warranted by the UV Supplier and as necessary to furnish written approval of the installation.
 - e. Revisiting the site to correct problems until installation and operation are acceptable.
 - f. Resolution of assembly or installation problems attributable to or associated with the UV Supplier's products and systems.
 - g. Conducting or assisting in equipment and system testing as specified.
 - h. Training of personnel in the O&M of products provided as specified.
- D. Contractor Scope of Supply: Provide materials, equipment, and appurtenances not supplied as part of UV Supplier scope of supply, but required for complete, functional, and operational UV System including, but not limited to:
- 1. Unloading and storing UV equipment at Site in accordance with manufacturer's instructions.
 - 2. Structural supports required to install UV reactors that are not supplied by UV Supplier; supports not directly connected to UV Reactors, for example pipe supports for upstream and downstream piping whether it supports UV reactor or not. Provide structural calculations to UV Supplier and Engineer.
 - 3. All the hardware, fasteners, anchor bolts, nuts, plates and angles necessary for the installation of the UV System. All hardware, fasteners, anchor bolts, nuts, plates, angles, etc. shall be Type 316 stainless steel.
 - 4. Drain valves, and associated piping necessary for proper operation of UV reactor.
 - 5. All conduit, fittings, supports, hubs and wiring including wire terminations and terminators necessary for the complete installation of the UV reactors, CPPs, instruments, analyzers, devices and HMIs/OIUs supplied as part of the UV System.
 - 6. All equipment supports, U-bolts, and hardware to install ancillary equipment supplied by UV Supplier. Ancillary equipment shall include UVT analyzers, control and power panels, and other equipment needed for a fully functional and validated UV system.

7. Provide onsite assistance to UV Supplier during equipment delivery, installation, functional testing and performance testing as defined in paragraph Field Quality Control.
8. Refer to UV Supplier's Shop Drawings for additional requirements.

1.02 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Water Works Association (AWWA): F110-12 Ultraviolet Disinfection Systems for Drinking Water.
 2. American National Standards Institute (ANSI).
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
 4. U.S. Environmental Protection Agency (USEPA): Final UV Disinfection Guidance Manual (UVDGM) - 2006 UVDGM.
 5. National Electrical Manufacturers Association (NEMA).
 6. National Fire Protection Association (NFPA): 70, National Electric Code (NEC).
 7. NSF International (NSF):
 - a. NSF/ANSI 60, Drinking Water Treatment Chemicals - Health Effects.
 - b. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - c. NSF/ANSI 372, Drinking Water System Components - Lead Content.
 8. UL.
 - a. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
 - b. 50E, Enclosures for Electrical Equipment, Environmental Considerations.
 - c. 508, Industrial Control Equipment.
 - d. 508A, Industrial Control Panels.

1.03 DEFINITIONS

- A. Definitions of Ultraviolet (UV) Reactor/Component Failure:
1. UV Lamps shall be deemed to have failed when:
 - a. UV Lamp fails to light when powered.
 - b. UV Lamp fails to achieve performance requirements for disinfection specified herein.
 - c. UV Intensity falls below UV Supplier's guaranteed end of life output (with UV Transmittance (UVT) greater than or equal to design value; sleeves cleaned by the UV Reactor's automatic cleaning system).

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2. UV Sleeves shall be deemed to have failed when:
 - a. UV Sleeve breaks or leaks water while operating within the conditions specified herein.
 - b. UV Sleeve output falls below UV Supplier's guaranteed end of life output immediately after sleeve cleaning by the UV Reactor's automatic cleaning system.
3. UV Ballasts shall be deemed to have failed when: UV Ballasts fail to properly operate UV lamps.
4. UV Intensity Sensors shall be deemed to have failed when:
 - a. UV Intensity Sensors are not able to be calibrated at the factory.
 - b. Duty Sensors drift out of calibration more than twice per month when checked with the reference intensity sensor per USEPA guidelines. Duty sensors shall be deemed out of calibration if intensity value at 100 percent lamp power differs from reference sensor intensity value by more than 20 percent absolute value.
5. UVT Analyzer shall be deemed to have failed when:
 - a. UVT Analyzer drifts out of calibration more than once per week when checked weekly against a bench-top spectrophotometer per USEPA guidelines. UVT analyzer shall be deemed out of calibration if UVT analyzer reading differs from bench-top UVT reading by more than 2 percent absolute value.
 - b. UVT Analyzer fails to operate properly.
6. UV Reactor shall be deemed to have failed when:
 - a. Minimum required Reduction Equivalent Dose (RED) or log inactivation, as specified herein, cannot be achieved under conditions that include flow, UVT, and lamp and sleeve life within design values.
7. Substantial Completion shall be granted when:
 - a. All testing, training, and O&M submittals have been reviewed and approved by Engineer and Owner.
 - b. Warranty period for equipment guarantees shall commence upon Substantial Completion.

B. Other General Definitions:

1. CPP: Control and Power Panel.
2. ELAF: End of lamp life aging factor.
3. Intensity: Power passing through a unit area perpendicular to direction of propagation. Describes magnitude of UV light measured by UV sensors in a reactor and with a radiometer in bench-scale UV experiments. Units of intensity are milliwatts per square centimeter (mW/cm^2). The term "S/S₀" indicates ratio of the measured intensity at a point in time to the measured intensity with a new lamp (after 100-hour burn-in) and new, clean sleeve, measured UVT greater than design UVT, and full lamp power.

4. HSC: Hydraulic System Center.
5. LPHO: Low pressure high output.
6. OIU: Operator Interface Unit. Graphical interface between each UV reactor and operator (user).
7. QSFF: Quartz sleeve fouling factor.
8. Reduction Equivalent Dose (RED): UV dose derived by entering the log inactivation measured during full-scale reactor validation testing into UV dose-response curve that was derived through collimated beam testing. RED values are always specific to the challenge microorganism used during experimental testing and validation test conditions for full-scale reactor testing. Indicates dose necessary, with full-scale UV System, to provide a level of inactivation of a specific organism (for example, MS-2 bacteriophage) equivalent to level of inactivation for the same organism achieved in a laboratory, using a collimated beam apparatus with a low pressure lamp producing UV energy at a wavelength of 254 nanometers on a water sample collected at the same time.
9. SCC: System Control Center.
10. UV Dose (Fluence): Indicates UV energy per unit area incident on a surface, typically reported in millijoules per square centimeter (mJ/cm²). UV dose received by a waterborne organism in a reactor vessel accounts for the effects on UV intensity of the absorbance of the water, absorbance of the quartz sleeves, reflection and refraction of light from the water surface and reactor walls, and germicidal effectiveness of UV wavelengths transmitted.
11. UV Supplier: Synonymous with UV System Manufacturer or Vendor. Responsible for specified Work of this section.
12. UV System: Synonymous with “UV Disinfection Equipment” or “UV Disinfection System”, which includes related UV equipment, materials, and appurtenances.
13. UV Transmittance (UVT): Indicates transmittance of ultraviolet light at a wavelength of 254 nanometers through water across a path length of 1 centimeter. UVT shall be expressed as a percentage.
14. Validated Dose (D_{val}): RED divided by VF as described in the USEPA UVDGM.
15. Validation Factor (VF): An uncertainty term that accounts for the uncertainty and bias associated with validation testing and full-scale installation as defined by the USEPA UVDGM.

1.04 SYSTEM DESCRIPTION

- A. UV System will be located in a drinking water treatment facility downstream of dual media filtration at Hicks WPP and Intermediate Transfer Pump Station at Hooper WPP. Facility will be heated and ventilated with a temperature range from 50 to 100F but is not air conditioned nor dehumidified.

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B. Provide UV System meeting the following design basis:

	Hicks WPP	Hooper WPP
Number of UV Reactors	2 (1 duty, 1 standby)	2 (1 duty, 1 standby)
Minimum Flow per Reactor	3.9 mgd	11.6 mgd
Average Flow per Reactor	5.0 mgd	14.0 mgd
Maximum Flow per Reactor	10.0 mgd	22.0 mgd
Water Temperature Range	7.6 C – 30.8 C	7.0 C – 33.0 C
Average Iron (mg/L as Fe)	0.01	0.02
Average Manganese (mg/L as Mn)	0.01	0.01
Turbidity	0.04 NTU	0.06 NTU
Design Criteria	2.5-log <i>Cryptosporidium</i> inactivation 2.5-log <i>Giardia</i> inactivation	2.5-log <i>Cryptosporidium</i> inactivation 2.5-log <i>Giardia</i> inactivation
Maximum Operating Pressure	60 psi	125 psi
Maximum UVT at 254 nm	94% at 6 mgd	94% at 18 mgd
Average UVT at 254 nm	92% at 8 mgd	92% at 20 mgd
Minimum UVT at 254 nm	90% at 10 mgd	90% at 22 mgd

C. UV Reactor Validation:

1. Under the USEPA UVDGM, validation shall provide minimum pathogen inactivation requirement over full range of flows, UV dose, and water characteristics at end of lamp life and under fouled quartz sleeve conditions.
2. Validated conditions for reactor shall include at least 80 percent UVT and flow rate at least 2 mgd above design value and log inactivation of *Cryptosporidium* and *Giardia* greater than or equal to 2.5.
3. Validation testing shall be based on a single challenge organism, meeting USEPA UVDGM requirements.
 - a. Validation surrogate organisms: Design based on MS2 phage. Include provisions for operation based on T1 phage.

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- D. UV disinfection equipment system shall be programmed, consistent with USEPA UVDGM, such that UVT greater than maximum validated UVT shall be considered equal to maximum validated UVT in the system programming and dose calculations. No extrapolation of system performance shall be allowed.
- E. UV Design Dose for System Sizing:
1. Reactors shall produce a Dval equal to or greater than 8.5 mJ/cm^2 . Calculated RED at design conditions shall be greater than product of Dval (for example, 8.5 mJ/cm^2 for 2.5-log Cryptosporidium) and VF calculated per the USEPA UVDGM for Cryptosporidium based on a single challenge organism.
 2. Minimum value of S/S_0 from intensity sensors within reactor shall be utilized when determining the Dval.
 3. Product of ELAF and QSFF shall be incorporated into UV design dose.
 4. ELAF provided by UV Supplier shall be based on the third party verified lamp output as a fraction of specified new lamp output after 100 hours of operation. Maximum ELAF allowed is 0.95.
 5. QSFF shall be 0.90.
 6. If an alternate ELAF is used, provide third party certification signed by a registered professional engineer of factor and conditions under which ELAF was determined.
- F. UV Reactor Headloss: Maximum 6.8 inches for Hooper WPP at 22 mgd and 1.7 inches for Hicks WPP at 10 mgd measured from inlet to outlet flange at maximum reactor flow rate.
- G. Input Voltage:
1. Hicks WPP:
 - a. CPPs – 480 V ac, 60-Hz, three-phase, four-wire +GND with a 15 kVA power supply including A/C unit. CPP units shall be equipped with door mounted disconnect switches with safety interlocks.
 - b. HSC – 480 V ac, 60-Hz, three-phase, three wire + GND, 2.5 kVA power supply.
 - c. SCC – 120V ac, 60-Hz, single-Phase, two Wire + GND, 1.8 kVA, 15A power supply.
 2. Hooper WPP:
 - a. CPPs – 480 V ac, 60-Hz, three-phase, four-wire +GND with a 21.7 kVA power supply including A/C unit. CPP units shall be equipped with door mounted disconnect switches with safety interlocks.

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- b. HSC – 480 V ac, 60-Hz, three-phase, three-wire + GND, 2.5 kVA power supply.
 - c. SCC – 120V ac, 60-Hz, single-Phase, two Wire + GND, 1.8 kVA, 15A power supply.
 - 3. UV System shall be capable of operating during a 30-percent voltage drop from nominal, without shutting down.
 - 4. UV system shall be capable of operating during an 8 millisecond voltage drop without shutting down.
- H. Design reactor components to handle pressures of up to 60 psi (4 bar).
- I. UV System shall be comprised of the following components:
- 1. UV reactor(s) including lamps, quartz sleeves, and appurtenances.
 - 2. Calibrated UV intensity sensor(s):
 - a. One duty sensor per bank of lamps.
 - b. Reference UV Sensor: Refer to Article Extra Materials. System shall be able to continue providing disinfection while UV intensity sensor is being calibrated or checked for calibration.
 - 3. Automatic Cleaning System or Hydraulic System Center (HSC):
 - a. One per reactor, required.
 - b. System shall be able to continue providing disinfection while automatic cleaning system is in operation.
 - 4. Local Control/Power Panel(s) (CPP):
 - a. One per UV reactor.
 - b. Includes lamp ballasts, PLC, remote I/O panels, OIU, Ethernet Switch (if required) and interconnecting power and control wiring between UV reactor and local control/power panel.
 - c. CPP units shall be equipped with door mounted disconnect switches with safety interlocks.
 - d. CPP units shall be equipped A/C units.
 - 5. Master UV System Control Center (SCC) PLC:
 - a. One per WPP.
 - b. System shall provide overall control of UV System and communicate as needed with Plant control system via Ethernet IP.
 - c. Includes PLC, OIU, Ethernet Switch, Fiber Optic Patch Panel and Uninterruptible Power Supply (UPS).
 - 6. Power Transformers/Conditioners: If required to accommodate incoming power voltage, variations, or quality.

1.05 SUBMITTALS

A. Action Submittals:

1. Package 1:
 - a. NSF-61 certification.
 - b. List mechanical components of UV system and complete catalogue information, descriptive literature, specifications, and identification of materials of construction, including spare parts.
 - c. Detailed UV reactor information including make/model, pressure rating, flange size, headloss curve, min/max flow rate, min/max UVT, min/max RED, reactor support requirements, quantity/location of UV lamps and intensity sensors, cooling water requirements, lamp cool-down/warm-up requirements, empty and full weight, and air-release/drain line connection details.
 - d. Validation Test Report: Full, detailed report with third party signature, raw data, and documentation of all reactor performance validation testing per the 2006 USEPA UVDGM. Include complete checklists 5.1 through 5.5 of the UVDGM, signed and dated by the Supplier.
 - e. Drawings showing plan layout, cross-sections, dimensions, critical clearances, installation requirements, and all interconnections and interface requirements (power, controls, instrumentations, etc.). Identify separately-mounted components, connections to other work, critical clearance requirements, interconnections and interface requirements, and the validated hydraulic configuration.
 - f. Summary of UV System control strategy including UV dose equation or calculations as a function of flow, UVT, VF, target organism inactivation, and lamp age/sleeve fouling factors and action spectra correction factor. Provide graph or table of min/max RED as a function of flow, UVT, S/S₀, and ballast intensity.
 - g. Provide summary calculations to show compliance of the minimum required UV dose at the worst-case design conditions that were utilized as the basis for the capital sizing of the UV System.
 - h. Estimated power consumption (kWh), harmonics generation, and power factor for individual UV reactor at 50 percent, 75 percent, and 100 percent ballast power levels if applicable.
 - i. Input power voltage, frequency, and phase requirements, total system maximum power load, power quality thresholds, and ballast turndown capabilities.

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- j. Specifications for all interconnecting cables between the UV equipment, including voltage ratings, insulation type, conductor material and cable/conductor outside diameter, maximum cable length, and cable terminator type and quantity.
 - k. Guaranteed replacement pricing as listed in Article Special Guarantee.
 - l. Manufacturer's printed installation instructions.
 - m. Details of control and power panels including internal and external panel layouts, dimensions, access requirements, materials of construction, bill of materials, electrical schematics, and wiring diagrams. Include software and hardware component details. Provide measurements to verify lead length limitations on communication circuit cabling have not been exceeded.
 - n. Installation List in United States for Cryptosporidium inactivation credit; including regulatory agency/utility for installation, capacity, and date of installation.
 - o. Lamp data including watt rating, lumen output data, 3rd party verified lamp aging factors, mercury content and lamp validation information.
 - p. Quartz sleeve data including materials of construction, transmittance data, sleeve fouling/aging factors, and sleeve validation information.
 - q. Complete description of the automatic lamp sleeve cleaning process and its maintenance requirements.
 - r. Details of duty and reference UV intensity sensors including sensor traceability and uncertainty from linearity, temperature response, spectral response, angular response, and long-term drift. Include calibration requirements necessary for compliance with UVDGM requirements.
2. Package 2:
- a. Detailed description of instrumentation and control system, including list of functions monitored, controlled, and alarmed. Describe automatic shutdown features and interfaces with both Hicks and Hooper water production plant Supervisory Control and Data Acquisition (SCADA) system.
 - b. Process and instrumentation diagrams and description of all functions monitored, controlled, and alarmed.
 - c. Control system block diagram(s) including the Human Machine Interface (HMI(s)), Programmable Logic Controller (PLC(s)), and control networks. Proposed layouts and development of all HMI screens for control of the UV disinfection system.
 - d. Fully documented electronic copy of ladder logic listings, I/O printouts, and cross-referenced printouts documenting programmable controller software program.

- e. Harmonic distortion calculations to show that total and individual current and voltage distortion under specified conditions are below the specified limits.
- f. Data on harmonic filters, or active filters, used to mitigate harmonics to IEEE 519 levels.
- g. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
- h. For CPP, provide PLC and Operator Interface programs on CD in both Beijer Automation software and PDF format. For SCC, provide PLC and Operator Interface programs on CD in both Rockwell Automation software and PDF format.
- i. For SCC, Fully documented ladder logic listings, function listing for function blocks not fully documented by ladder logic listings, cross-reference listings, and operator interface configuration documentation.
- j. List of replaceable system components along with their expected replacement frequencies, duration of life warranties, guaranteed replacement prices, and calibration frequencies. Include a list of special tools required for checking, testing, parts replacement, and maintenance.
- k. Prior to delivery provide manufacturer's instructions for materials requiring special shipping, storage, or handling requirements.
- l. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
- m. Draft Operation and Maintenance Manual.
- n. Factory Acceptance Test Plan: Provide a narrative of the test plan and data to be recorded and analysis to be completed, including all forms for recording data during the test.
- o. Functional Test Plan: Provide a narrative of the test plan and data to be recorded and analysis to be completed, including all forms for recording data during the test.
- p. Performance Test Plan: Provide a narrative of the test plan and data to be recorded and analysis to be completed, including all forms for recording data during the test.

B. Quality Control Submittals:

- 1. Final Factory Acceptance Test data sheets and witness report.
- 2. UV Supplier's Certificate of Proper Delivery for all UV Supplier supplied equipment.
- 3. UV Supplier's Certificate of Proper Installation for all UV Supplier supplied equipment, including factory disassembly and field reinstallation instructions.

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4. Functional Testing Report: Provide a narrative and data summary of the Functional Testing discussing each element requiring testing, the tests performed, and the results. Functional Testing is not complete until this report is submitted and accepted by the Engineer.
5. Performance Testing Report: Provide a narrative and data summary of the Performance Testing discussing each element requiring testing, the tests performed, and the results. Performance Testing is not complete until this report is submitted and approved by the Engineer.
6. Resume or qualifications for UV system operations trainer.
7. Training agenda and presentation.
8. Anchorage and bracing calculations, as required by Section 01 88 15, Anchorage and Bracing.

C. Contract Closeout Submittals:

1. Final Operation and Maintenance Manuals as specified in the Division 01, General Requirements including detailed wiring diagrams for panels and equipment.
2. List of all original equipment by model and part number (detailed bill of materials). List manufacturer names, addresses, and phone numbers.
3. Service records for maintenance or calibration reports for calibration performed during construction or testing activities.
4. Spare parts documentation.
5. Warranty information.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. All packages to be clearly identified as to project destination and contents. Package and/or crate to protect all equipment from damage during shipping.
2. Deliver the equipment and appurtenances to the location designated by the Owner.
3. Polish and protect all surfaces from corrosion and damage during shipment, normal handling and installation.
4. Carefully pack all equipment for shipment and protect all electrical equipment from moisture damage.
5. Package UV equipment in subcomponents in size/weight that allows for field assembly by the Installing Contractor. Coordinate maximum allowable dimensions and weights with Installing Contractor.

6. Each component shall be identified with durable labeling other than paper that is resistant to sunlight exposure and moisture. A UV Supplier representative will be available for assistance as follows:
 - a. Inspecting the equipment upon arrival at the site to ensure all equipment has been delivered in good order and that no damage has occurred during delivery.
 - b. Identification of and notification to the Owner and the Engineer of discrepancies between the shipping lists and the equipment received.

B. Delivery and Storage:

1. Each component will be identified with durable labeling other than paper that is resistant to sunlight exposure and moisture. A UV Supplier representative will be available for assistance during this time if requested by the Owner. The UV Supplier shall assist the Installing Contractor as follows:
 - a. Inspecting the equipment upon arrival at the site to ensure all equipment has been delivered in good order and that no damage has occurred during delivery.
 - b. Identification of and notification to the Installing Contractor and the Engineer of discrepancies between the shipping lists and the equipment received.
 - c. Identification of all equipment to ensure all equipment is installed in its intended place.
2. The UV Supplier shall complete the Manufacturer's Certificate of Proper Delivery upon satisfactory installation of the UV System.

1.07 SPECIAL GUARANTEE

- A. Guarantee each item of mechanical and electrical equipment, instruments, and devices furnished under this Contract against defects including, but not limited to, the following:
 1. Defective material or workmanship or both.
 2. Leakage, breakage, or other failure which might occur under normal and proper operation of the equipment under the specified conditions.
 3. UV reactor/component failure, as defined herein, during guaranteed life.
- B. Replace each item of equipment or part thereof proving to be defective.
- C. Bear expense of replacement including, but not limited to, cost of labor, supervision, traveling, replacement parts, transportation, and shipping cost. Supplier shall coordinate and facilitate.

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- D. Provide a UV system performance guarantee for a period of 1 year from Engineer's final acceptance of Functional, Performance, and Acceptance Test Periods.
- E. Guarantee life and replacement pricing for UV lamps, quartz sleeves, ballasts, and duty and reference UV intensity sensors following Engineer's final acceptance of Performance Test.
1. Replacement Pricing:
 - a. The UV Supplier shall provide Guaranteed Lamp Replacement Prices, Guaranteed Quartz Sleeve Replacement Prices, Guaranteed Ballast Replacement Prices, Guaranteed Duty Sensor Calibration Prices, Guaranteed Reference Sensor Calibration Prices, and Guaranteed Duty Sensor Replacement Prices, as a cost per individual item and as a cost for the total system. The UV Supplier shall guarantee that items may be purchased by the Owner at this price or lower any time up to 20 years following Substantial Completion of the installation contract, with the guaranteed prices being adjusted by the Consumer Price Index (CPI). Freight charges to the Owner's plant for this supply are not to be included.
 - b. The UV Supplier shall warrant the Lamps, Quartz Sleeves, Ballasts, and Duty and Reference UV Intensity Sensors for the Guaranteed Life following final acceptance after Substantial Completion. If the UV Supplier is not the item's Manufacturer, the Warranty shall be provided, in writing, directly to the Owner by the item's Manufacturer.
 2. UV Lamps:
 - a. LPHO lamps shall be warranted for at least 15,000 hours, prorated after 9,000 hours.
 - b. If lamp fails within initial prorated period, provide replacement lamp free of charge.
 - c. If lamp fails after initial prorated period and before guaranteed life use the following formula to determine discounted price for replacement lamps:
$$\text{Lamp Price} = (\text{Lamp Operating Hours} - 9,000 \text{ hrs}) / (\text{15,000 hrs} - 9,000 \text{ hrs}) \times \text{Guaranteed Lamp Cost.}$$
 3. Ballasts:
 - a. Warranted for 10 years, prorated after 2 years.
 - b. If ballast fails within initial prorated period, provide replacement ballast free of charge.

- c. If ballast fails after initial prorated period and before guaranteed life, use the following formula to determine discounted price for replacement ballast:

$$\text{Ballast Price} = (\text{Ballast Operating Time} - 2 \text{ yrs}) / (\text{10 yrs} - 2 \text{ yrs}) \times \text{Guaranteed Ballast Cost.}$$

4. Quartz Sleeves:

- a. Warranted for at least 10 years, prorated after 1 year.
- b. If quartz sleeve fails within initial prorated period, provide replacement sleeve free of charge.
- c. If quartz sleeve fails after initial prorated period and before guaranteed life use the following formula to determine discounted price for replacement sleeve:

$$\text{Sleeve Price} = (\text{Sleeve Operating Time} - 1 \text{ yr}) / (\text{10 yrs} - 1 \text{ yr}) \times \text{Guaranteed Sleeve Cost.}$$

5. UV Sensors:

- a. Warranted for at least 5 years, prorated after 1 year.
- b. If UV sensor fails within initial prorated period, provide replacement sensor free of charge.
- c. If UV sensor fails after initial prorated period and before guaranteed life use the following formula to determine discounted price for replacement sensor:

$$\text{Sensor Price} = (\text{Sensor Operating Time} - 1 \text{ yr}) / (\text{5 yrs} - 1 \text{ yr}) \times \text{Guaranteed Sensor Cost.}$$

1.08 BASIS FOR HARMONIC COMPUTATIONS:

A. Normal Source Current Harmonic Distortion:

- 1. Compute individual and total current harmonic distortion at input terminals of the power distribution center in accordance with IEEE 519.
 - a. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current I_L shall not exceed values specified in Table 1 below:

Table 1	
Individual Harmonic Order (Odd Harmonics)	Harmonic Current Distortion Percent of Max. Demand Load Current I_L
$3 < h < 11$	4.0
$11 < h < 17$	2.0
$17 < h < 23$	1.5

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Table 1	
Individual Harmonic Order (Odd Harmonics)	Harmonic Current Distortion Percent of Max. Demand Load Current I_L
23 < h < 35	0.6
35 < h < 50	0.3
Total Demand Distortion (TDD)	5.0

2. Voltage Harmonic Distortion: Compute voltage harmonic distortion at the input terminals to the PCCs. THD shall not exceed 8 percent, and individual voltage harmonic distortion shall not exceed 5 percent.
3. Furnish series reactors, harmonic filters, transformers or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one UV system from adversely affecting operation of other UV systems or AC drives supplied from same transformer or same bus.

1.09 EXTRA MATERIALS

- A. UV Supplier shall furnish, tag, and box for shipment and storage the following for each – Hicks WPP and Hooper WPP:

Item	Quantity
UV Lamps	Hicks WPP – 8 Hooper WPP – 16
Sleeves	Hicks WPP – 8 Hooper WPP – 16
Ballasts	Hicks WPP – 2 Hooper WPP – 2
Ballast Cooling Fan	Hicks WPP – 2 Hooper WPP – 2
Duty UV Sensor	One complete set for one reactor
Reference UV Sensor	Three total for each WPP
Cable/Conductor Terminations	two of each type used; of sufficient length to provide for two more cable runs

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Item	Quantity
Cleaning System Wiper Rings	Hicks WPP – 8 Hooper WPP – 16
O-ring Seals	Hicks WPP – 8 Hooper WPP – 16
Programmable Controller Spare Parts	One of each type chassis power supply used One of each type PLC processor used One of each type of I/O module used One of each type of mounting chassis used One of each type of communications module used
Industrial Ethernet network switches for Ethernet communications between PLCs and OIUs	One per UV control panel
Eye Protective Goggles or Face Shield	One per WPP
Special tools required to maintain or dismantle	One complete set per WPP

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

- A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
1. Use or reuse of components and materials without a traceable certification is prohibited.

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- B. The complete electrical assembly shall meet all requirements of the National Electrical Code (NEC), the National Electrical Manufacturers Association (NEMA), the National Fire Protection Association (NFPA), UL and all applicable local electrical codes.
- C. Components, including equipment, coatings and other parts of the UV System, shall comply with American Water Works Association (AWWA) standards, unless specified otherwise.
- D. All terminal point connections shall be ANSI standard flanges.

2.02 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of: Trojan Technologies (London, ON); Flex 100 Series.
- B. No “or-equal” or substitute products will be considered.

2.03 GENERAL

- A. Products that will be in contact with potable water shall have NSF 61 certification.
- B. Electrical assembly shall meet requirements of NFPA 70 (NEC), NEMA, and applicable local electrical codes.
- C. Components, including equipment, coatings and other parts of UV System shall comply with AWWA standards, unless specified otherwise.
- D. Terminal point connections shall be ANSI standard flanges.
- E. Hardware, fasteners, anchor bolts, nuts, plates, and angles shall be Type 316 stainless steel.
- F. Mating flanges shall be as required in pipe schedule. Bolts and nuts shall be Type 316 stainless steel. Gaskets shall be ethylene propylene diene monomer rubber (EPDM).

2.04 UV REACTOR

- A. General Requirements:
 - 1. Materials of Construction:
 - a. External: Welded Type 2205 duplex stainless steel, pickled, passivated, and bead-blasted for uniform external finish.

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- b. Internal: Internal metal parts constructed of Type 316L stainless steel, pickled, and passivated.
 - c. 36 inch AWWA Class B flanged inlet/outlet connections.
 - d. Internal nonmetallic materials shall be suitable for continuous exposure to UV light.
2. Quartz Sleeves:
 - a. High purity, rated for maximum possible UV transmittance.
 - b. Accounted for in UV dose and validation.
 - c. Each lamp shall be enclosed in an individual quartz sleeve, sealed with compressed O-rings and a compression plate.
 - d. Each quartz sleeve shall be independently sealed within reactor.
 3. Designed such that operating personnel at plant can change lamps without draining reactor.
 4. Provide with access port for easy maintenance of quartz sleeves, cleaning system, and sensor calibration and maintenance.

B. UV Lamps:

1. Low Pressure-High Output (LPHO).
2. Filament: Rugged to withstand shock and vibration.
3. Lamp Base: Resistant to UV.
4. Operated by electronic or electromagnetic ballasts with multiple power settings with 1 percent power increments ranging from at least 30 percent to 100 percent maximum power.
5. Guaranteed for a minimum number of operation hours prior to lamp output reaching the ELAF, as defined in Special Guarantee.
 - a. Minimum of four on/off cycles shall be allowable for lamps every 24 hours.
 - b. At end of guaranteed lamp life, lamp output weighted for germicidal emission spectrum, using a weighting equivalent to that used by UV Supplier's intensity sensor, shall be greater than or equal to 95 percent of new lamp output, as measured in the field by using system's UV intensity reference sensors.
 - c. At highest power setting, if intensity reference sensor reading or average of reference sensors for a clean lamp is less than or equal to 95 percent of intensity sensor reading(s) for a new lamp, then end of lamp life shall be considered to have been achieved.
 - d. If UV Supplier submits an alternative ELAF, then submitted value shall replace "95 percent" specified above.

C. UV Lamp Quartz Sleeves:

1. Open end(s) of lamp sleeve shall be sealed by means of an O-ring and Type 316 stainless steel compression plate.
2. Lamp sleeves shall be domed at one end.

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3. Guaranteed for a minimum duration of operation (in years), as defined in Special Guarantee.
4. Manufacturer: General Electric; Type 214, fully annealed clear fused quartz tubing.

D. Intensity Sensor:

1. Use germicidal UV sensors as defined in the USEPA UVDGM. Do not use “wet” intensity sensors.
2. UV Sensors shall be located inside the reactor and contained with protective quartz sleeves.
3. Sensors shall incorporate SiC diodes and provide NIST-traceable measurement with a total absolute uncertainty of 15 percent or less at an 80 percent confidence level.
4. Sensors must meet the requirements of the EPA 815-R-06-007. Sensors must filter out wavelengths below 240 nm and have a spectral response peaking between 250 nm and 280 nm with less than 10 percent coming from wavelengths greater than 300 nm.
5. The complete sensor assembly and the internal circuit board containing the diode shall each be serialized.
6. The quartz sleeve for the UV intensity sensor shall be cleaned by the mechanical wiping system.
7. Provide minimum of one duty UV sensor for every 16 lamps, or 1 lamp bank.
8. Guaranteed for a minimum duration of operation (in years), as defined in Special Guarantee.

E. Hydraulic System Center:

1. One per reactor: 305HSC1 and 305HSC2.
2. Each HSC is floor mounted.
3. Automatically initiated and controlled cleaning cycle capable of cleaning lamp sleeves and UV sensor sleeves.
4. The HSC shall be driven by a hermetically sealed magnetically coupled hydraulic drive. The drive system shall be designed such that all hydraulic connections are outside the UV reactor. The hydraulic fluid used shall be biodegradable.
5. Wiper seals shall be changeable from the endplate and without accessing the interior of the UV reactor.
6. Fully operational while still providing disinfection.
7. Field adjustable via operator interface; manual cleaning system control available through operator interface.
8. Automatic chemical cleaning systems connected externally to the UV reactor(s) will not be considered acceptable.

2.05 CONTROL PANELS

- A. At each site, provide one System Control Center (SCC) and two Control and Power Panels (CPP) (one CPP per UV Reactor):
1. Tag numbers shall be the same at both sites:
 - a. SCC: 300SCC.
 - b. CPPS: 305CPP1 and 305CPP2.
- B. General:
1. Prewire panels to maximum extent possible, requiring only field connections for power and field devices.
 2. Prewire CPP and SCC to the extent possible. All conduit, fittings, supports, hubs and wiring including wire terminations and terminators necessary for the complete installation of the UV reactors, CPPs, instruments, analyzers, devices and HMIs supplied as part of the UV System.
 3. For communication circuits, provide cable and connectors per device manufacturer's recommendations. Provide measurements to verify lead length limitations on communication circuit cabling have not been exceeded.
 4. Electrical cables shall have jackets that will not degrade after prolonged exposure to UV light.
 5. Provide removable eye bolts to facilitate sling handling of each panel. Eyebolt mounting shall be part of structural support bracing to distribute stresses and enclosure weight while sling handling enclosures during installation.
 6. Panel-mounted computers shall be installed in field and are not to be shipped with panel.
 7. Overall system monitoring and control shall be through the SCC.
 8. Power distribution and lamp driver control for each UV reactor shall be through the associated CPP. The CPP shall house all lamp drivers.
 9. Signal wiring interfacing the UV reactor with the CPP, the CPPs with the SCC and the SCC with the plant SCADA system, shall be as shown on the Contract Drawings.
 10. The external running cable length between SCC and CPPs shall be 100 feet.
 11. The external running cable length between CPPs and the UV reactors shall be 65 feet.
 12. Each CPP enclosure shall be floor mounted or a concrete pad and each SCC shall be rack mounted.

C. Fabrication:

1. Construct with structural reinforcements to ensure a plane surface, limit vibration, and to provide rigidity during shipment, installation, and operation without distortion or damage.
2. Panel seams shall be continuously welded and ground smooth to be undetectable after painting.
3. Cabinets shall have a total clearance of not less than 2 inches from face of backplate mounted devices to rear of door mounted devices. Cabinets and internal components shall be secured and reinforced to permit a 90 degree rotation for transporting and installation. On SCC backplate, provide interior LED light fixture with door switch and white duplex convenience outlet with on/off circuit breaker powered from 120V ac power feed.
4. Construct panel layout and equipment spacing to allow for device removal, calibration, and maintenance without disassembly of adjacent devices.
5. Do not perforate external surface of enclosure for purpose of mounting enclosure components (both internal and external) without prior permission of Engineer. Enclosure components requiring such fixation shall utilize fusion welded capacitor discharge type studs.
6. Isolate electrical components from wetted parts.
7. Arrange components in enclosure such that failure of a component requires removal of failed component only.
8. Systems where groups of components are enclosed and serviced as a subsystem will not be permitted.
9. Internal wiring shall run through ducts.
10. Provide 24V dc UPS circuit within each SCC enclosure to power PLCs, and OIUs, and a white duplex outlet on backplate for panel use of electronic instruments.
11. Terminal Blocks:
 - a. Install terminal blocks, relays, and other wiring and devices on panel backplate.
 - b. Separately mount and identify terminal strips used for power, analog inputs, analog outputs, digital inputs, and digital outputs.
 - c. Order of terminal block sections, one for each card, shall match order of cards as they appear in rack. Each terminal block section shall match numbering convention of card.
 - d. Provide terminal blocks for used and spare PLC I/O cards in SCC.
12. Coordinated breaker protection required from a control panel main breaker, to downstream distribution breakers.
13. Digital, analog and power devices such as relays, terminals and wire must be separated and clearly marked.

14. Control Wiring:
 - a. Segregated within each panel based on voltage.
 - b. Voltages above 120 volts shall be separated by a solid metal barrier.
 - c. Analog and discrete control wiring shall be kept separate from 120V ac, and 480V ac and higher.
 - d. Control: Minimum 14 AWG for 120V ac and 16 AWG for 24V dc.
 - e. Analog: Minimum 18 AWG.
 - f. Size wire for connected loads.
 15. OIU:
 - a. Devices mounted on front door shall be suitable for application and selected to match each other and present a coordinated aesthetically pleasing functional arrangement.
 - b. Symmetrically arrange devices and functionally group devices to enable operators to easily locate groups of devices or individual devices to control the process.
 - c. Install devices mounted on enclosure front door rigidly and within view level heights.
 - d. Center of OIU shall be installed at approximately 5 feet above surrounding floor for ease of operation. Arrange other devices such as selector switches, pushbuttons and indicating devices below.
- D. Safety Interlock:
1. Prevents panel from being opened when main panel electrical disconnect is closed. Alternatively, interlock may be provided to disconnect power from panel when door is opened.
 2. In accordance with panel ratings of UL, local ordinances, and Plant safety rules noted herein.
 3. Manufacturer and Product: ABB; XT1.
- E. Enclosure:
1. House electrical components in Type 304 Stainless Steel enclosure.
 2. Enclosure shall be rated NEMA 4X, ventilated with cooling suitable for indoor installation.
 3. All panels shall be lockable.
 4. Doors:
 - a. Open through 180 degrees without restriction (unless provided with a door stop).
 - b. Provide three-point latch assembly for 3-foot-high and larger doors.

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5. Construct to accommodate accessories such as instrument air, power, power supplies, mounting hardware, terminal blocks, and signal conditioning or conversion equipment that may be necessary for monitored and controlled equipment mounted in enclosure.
6. Internal Back Panel: Removable type, mounted 2 inches clear from rear of panel.
7. Do not install devices on side plates.
8. Supply enclosures containing PLCs or OIUs with print pockets, located on inside bottom of enclosure door.
9. Factory Finish:
 - a. Exterior: Stainless Steel.

F. Harmonics:

1. Limits: In accordance with IEEE 519.
2. Provide harmonic filters and any other equipment required to meet IEEE 519 standards. Harmonic filters, if required, will be powered and controlled from each CPP.

G. Cooling and Heating:

1. Maximum Temperature:
 - a. Provide cooling to prevent high temperatures from shortening life of equipment mounted inside.
 - b. No location within panel or interior of equipment mounted inside shall reach temperatures higher than 40 degrees C.
2. Minimum Temperature:
 - a. Electric heating to prevent low temperatures from causing condensation or freezing of equipment mounted inside.
3. Cooling Without Air Exchange:
 - a. Use solid-state cooling equipment or refrigeration.
 - b. Heat dissipation portion of cooling unit shall be designed for use in areas with heavy particulate contamination and capable of running extended periods without cleaning.

H. Local UV Reactor CPPs:

1. Connected electrical load for each UV disinfection system including A/C units is not to exceed 21.7 kVA for Hooper WPP and 15kVA for Hicks WPP.
2. Power distribution and control for each UV reactor shall be through associated CPP. CPP shall house power supplies and control hardware for reactor.

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3. Cable and Flexible Conduit:
 - a. Provide for connecting UV reactor to associated CPP.
 - b. Cable: Rated for power and temperature operating conditions.
 - c. Maximum cable length is estimated to be 65 feet to the UV reactor and 100 feet to the SCC.
 4. CPP shall include complete power distribution system for ballasts/lamps and ancillary equipment associated with each reactor. Electrical system shall comply with local electrical code requirements.
- I. System Control Center (SCC):
1. Each WPP shall be provided with one SCC.
 2. Each SCC requires one 120V, 1 Phase, 2 Wire + GND, 60Hz, 1.8 kVA, 15A power supply.
 3. The SCC shall be rack mounted.
 4. The SCC enclosure shall be rated NEMA 4X, Type 304 stainless steel.
 5. The SCC is equipped with a PLC controller.
 6. Control and monitoring of UV treatment system shall be provided through SCC. SCC shall support the following functions:
 - a. UV reactor start/stop.
 - b. UV system communications to plant SCADA system via Fiber Optic cable:
 - 1) Provide Fiber Optic Patch Panel (FOPP) sized to provide terminations for each individual fiber entering or leaving the panel.
 - 2) FOPP shall use ST Bayonet style fiber connectors for OM1 Multimode fiber. Also provide ST-SC OM1 fiber jumpers from the FOPP to the Ethernet switch.
 7. The operator interface(s) shall be menu driven and shall display the following system information when prompted: reactor status, individual lamp status, lamp operating hours, contaminant log reduction, UV transmittance, UV intensity, power level, alarms, alarm history.
 8. The most recent alarms shall be displayed on the operator interface when prompted, recorded by alarm type, date and time of occurrence, and date and time of correction (if available).
 9. PLC shall be interconnected to UV reactor CPP PLCs and treatment facility PLC through UV treatment facility Ethernet control network:
 - a. Ethernet switch to be Hirschmann Bobcat series (BRS20) managed switch. Ports shall be as required.
 10. OIU shall communicate with UV reactor CPP PLCs using the following communications methods: Ethernet/IP.

2.06 INSTRUMENTATION AND CONTROL

A. General:

1. One CPP shall be provided for each UV reactor. Control hardware and software for a given reactor shall be contained within associated CPP.
2. Provide instrumentation and control which allows for UV disinfection process to be fully automated and deliver required UV dose under conditions of varying flow rates, UV lamp intensity, and varying UV transmittance.
3. Program functions, I/O addresses, and internal registers within SCC PLCs shall be accessible by Owner's SCADA system.
4. Coordinate register units, ranges, and conventions to facilitate data exchange.
5. Provide native format electronic copies of software installed in UV Supplier's SCC PLC and OIUs, annotated to carefully detail program instruction functions and purposes. Minimum control, monitoring and alarm signals/information are detailed in Article D.

B. Programmable Controllers:

1. General: Provide control devices, instrumentation, panels, electrical components and wiring, and all ancillary devices for a complete functional system in accordance with general control requirements specified in Section 40 99 90, Package Control Systems (PCS).
2. CPP PLC: Trojan branded controller with Wago IO.
 - a. Communications: Modbus.
3. SCC PLC:
 - a. Communications:
 - 1) 10/100 Mbps EtherNet/IP communications ports.
 - 2) 10/100 Mbps EtherNet/IP communications for OITs and Plant SCADA:
 - a) SCADA connection over Fiber Optic Cable.
 - 3) Modbus.
 - b. Power Supply Module: As required.
 - c. Digital Input Module.
 - d. Digital Output Module: 24V dc relay outputs with interposing relays.
 - e. Analog Input Module: 4 mA to 20 mA.
 - f. Analog Output Module: 4 mA to 20 mA.
 - g. Manufacturer and Product: Allen-Bradley.

C. Operator Interface Unit (OIU):

1. Panel-mounted graphical operator interface capable of bidirectional communication with PLC-based control system.
2. Mount in each CPP and SCC.
3. Include cables and ports to interface with PLC control system, personal computers, and external compact flash drives.
4. Graphic Display Screens: Match configuration of plant control system workstations with respect to color usage conventions, general formatting, and screen navigation.
5. Manufacturer and Product:
 - a. CPP: Beijer.
 - 1) Size: 7 inches.
 - b. SCC: Allen-Bradley; PanelView Plus, Touch screen only format.
 - 1) Size: 12 inches.
6. The operator interface shall be menu driven and shall display the following system information when prompted: reactor status, individual lamp status, lamp operating hours, UV dose, UV intensity, power level, alarms, alarm history.
7. The most recent alarms shall be displayed on the operator interface when prompted, recorded by alarm type, date and time of occurrence, and date and time of correction (if available).

D. Control System Hierarchy:

1. UV Supplier shall apply through hardware and PLC/OIU software the following standard control hierarchy/modes to SCADA controlled devices:
 - a. Each reactor is always in Remote/Automatic with the ability to locally override various setpoints (Requested Flow Target, Flow, UVT for example).
 - b. Individual UV Sections can be selected to LOCAL ON (100 percent power), OFF, or REMOTE. This selection is handled via HMI selection at the CPP.
2. Operator shall have capability to open/close valves or adjust position from SCC when applicable. Operator shall have the capability to override valve operation from SCADA.
3. Provide safeguards and warnings to prevent accidental change of state.
4. Functional Requirements:
 - a. UV control system shall calculate UV RED for both *Cryptosporidium* and *Giardia* based on flow rate through UV reactor, UV transmittance, and UV intensity measurements in UV reactor.

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- b. UV Control System shall apply VF, calculated if required, and report Dval and log inactivation of *Giardia* and log inactivation of *Cryptosporidium*.
- c. UV reactor flow meter shall be hardwired to its associated CPP PLC.
- d. UV transmittance signal shall be hardwired to SCC.
- e. UV control system shall maintain required UV dose and log inactivation and send an alarm to plant control system if it is unable to maintain dose and log inactivation setpoints.
- f. UV control system shall monitor for equipment failure or malfunction and shut down reactor in response to such a failure.
- g. UV control system shall totalize the flow of water on a daily basis that is on-spec, off-spec and total treated flow.
- h. Plant main SCADA shall provide permission to start a UV reactor.
- i. Plant main SCADA shall control the operation of UV Drain Valve 306FCV by communicating through the SCC.
- j. UV Supplier shall provide control and monitoring of influent and effluent valves.
 - 1) Coordinate with systems integrator regarding details of interfacing and communications with this equipment.
 - 2) In the event of production of off-spec water, the stand-by reactor and corresponding valves shall be brought online, followed by taking the operational reactor and corresponding valves offline.
- k. UV Supplier and Owner's System Integrator shall provide synchronization mechanisms and logic within their systems such that UV Control System OIU and SCADA alarm display and acknowledgement maintains synchronization.

E. Inputs/Outputs:

- 1. The following signals shall be available through PLC Ethernet Network as a minimum:
 - a. Effluent Valve Position Status.
 - b. Influent Valve Open Status.
 - c. UV Reactor Flow Rate.
 - d. UV Reactor Run Enable Permissive.
 - e. Feed Water UV Transmittance.
 - f. UV Dose Target or Inactivation Target Setpoint.
 - g. Backup UV Reactor Status (Standby, Offline).
- 2. The following signals shall be sent to plant PLC via Ethernet:
 - a. Inputs:
 - 1) High Reactor Temperature.
 - 2) High Cabinet Temperature.

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- 3) Ballast Power Level.
- 4) Ballast Ground Fault.
- 5) Lamp Section ON/OFF status.
- 6) Reactor Running Status.
- 7) Common Warning Out.
- 8) Common Alarm Out.
- 9) Reactor Influent Valve Open Command.
- 10) Reactor Influent Valve Close Command.
- 11) Reactor Influent Valve Open Status.
- 12) Reactor Influent Valve Closed Status.
- 13) Reactor Influent Valve In Remote.
- 14) Reactor Effluent Valve: Position Command.
- 15) Reactor Effluent Valve: Position.
- 16) Reactor Effluent Valve: In Remote.
- 17) UV Drain Valve: Position Command.
- 18) UV Drain Valve: Position.
- 19) UV Drain Valve: In Remote.
- 20) System Ready.
- 21) Flow Rate.
- 22) Daily treated water volume (MG).
- 23) Daily off-spec water volume (MG).
- 24) Daily on-spec water volume (MG).
- 25) Daily % off-spec water (%).
- 26) Daily treated water volume for the previous day (MG).
- 27) Daily off-spec water volume for the previous day (MG).
- 28) Daily on-spec water volume for the previous day (MG).
- 29) Daily % off-spec water (%) for the previous day.
- 30) Total running monthly treated water volume (MG).
- 31) Total running monthly off-spec water volume (MG).
- 32) Total running monthly on-spec water volume (MG).
- 33) Total running monthly % off-spec water (%).
- 34) Daily maximum flow per reactor.
- 35) Daily minimum UVT.
- 36) Daily minimum UV dose (mJ/cm²).
- 37) Daily number of off-spec events.
- 38) RED (mJ/cm²).
- 39) UV Intensity (per section).
- 40) Validated Dose (mJ/cm²).
- 41) Required UV Dose (mJ/cm²).
- 42) Log Inactivation of *Giardia*.
- 43) Log Inactivation of *Cryptosporidium*.
- 44) Lamp Run Time (Hours).

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3. As a minimum, UV control system shall provide the following minor alarms to plant PLC, but shall not automatically shut down UV reactor:
 - a. Lamp run time hours exceeded.
 - b. UV intensity sensor calibration check required.
 - c. Measured UVT above validated range, revert to maximum validated UVT.
 - d. Loss of UVT signal, revert to last known UVT.
 - e. Loss of Flow signal, revert to last known flow.
 - f. Measured flow below validated range, revert to minimum validated flow.
 - g. SCADA communication failure.
4. As a minimum, UV control system shall provide the following major alarms to plant PLC but shall not shut down UV reactor:
 - a. Measured UVT below validated range.
 - b. Measured flow above validated range.
 - c. Low UV dose.
 - d. UV intensity sensor signal loss.
 - e. Effluent Valve Failure to Open.
 - f. Effluent Valve Failure to Close.
 - g. Influent Valve Failure to Open.
 - h. Influent Valve Failure to Close.
5. As a minimum, UV control system shall provide the following critical alarms to plant PLC and shall automatically shut down duty UV reactor and activate standby UV reactor:
 - a. Lamp failure.
 - b. Ballast failure.
 - c. Low or no flow, not associated with a loss of communication.
 - d. Cabinet high temperature.
 - e. High reactor/lamp temperature.
 - f. Ballast high temperature.

2.07 SAFETY EQUIPMENT

- A. Provide goggle or glasses that blocks UV light wavelengths between 200 nm and 400 nm.

2.08 ACCESSORIES

- A. Equipment Identification Plates: Provide 16-gauge stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.

- B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.
- C. Anchor Bolts: Type 316 stainless steel, sized by Installing Contractor.

2.09 SOURCE QUALITY CONTROL

A. General:

1. Do not ship UV System until factory test report is approved by Engineer and Owner.
2. Factory test shall demonstrate that each individual UV System operates as specified.
3. Owner and Engineer may elect to witness tests. Costs to witness shall be responsibility of Owner.
4. Components shall be fully assembled and hydrotested at 1.5 times design pressure at factory prior to shipment.

B. Factory Acceptance Test (FAT):

1. The UV Supplier shall be responsible for the FAT that shall be conducted by the UV Supplier after the Shop Drawings are approved and before UV System is shipped to the Site.
2. The UV Supplier shall factory test all major UV System components of the UV System during a single test session for compliance with the construction and functional requirements specified herein.
3. The UV Supplier shall submit a FAT Plan, for approval by Engineer that will demonstrate the full operability of UV Reactors. The test plan shall include, but is not limited to the testing of the delivery of the UV dosage, the lamps, the intensity sensors, the cleaning system, CPP for each of the UV reactors, the SCC for each of the treatment plants, the instrumentation and controls for each of the reactors, and operator interface units. The test will verify the functions of the UV System via simulation or other methods. The PLC and HMI hardware and software is to be set up to allow thorough testing of controls and communications. The scope of the FAT shall demonstrate that each individual component of the UV System operates as specified.
4. For the FAT, the UV Supplier is to assemble all CPPs and SCCs to demonstrate the complete UV System. Provide all necessary communications links between the respective panels and computers to simulate the complete UV System. The UV Supplier shall provide 3 weeks' advance notice prior to conducting the FAT.

- C. Factory Test Plan and Report:
1. Develop and submit test plan. Plan shall include, but not limited to:
 - a. Daily test schedule for duration of test.
 - b. Delivery of UV dosage.
 - c. Lamps.
 - d. Intensity sensors.
 - e. Cleaning system.
 - f. Control power panel for each reactor.
 - g. Instrumentation and controls for each reactor.
 - h. Operator interface units.
 2. Upon conclusion of test, submit test report documenting tests performed, items witnessed, and results.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The UV Supplier shall furnish instructions and supervise the Work of the Installing Contractor regarding installation of the UV System. The Installing Contractor shall install the UV System in strict accordance with UV Supplier's instructions. Due to necessity to install UV system CPP and SCC in subcomponents, UV Supplier shall be responsible for completing any field wiring within the UV CPP and SCC necessary to provide a complete system to the Owner.
- B. Provide a qualified field technical representative to supervise delivery and off-loading and on-site supervision of installation of the UV System by the Contractor and to provide Certification of Proper Installation.
- C. The UV Supplier shall provide direct supervision of the Work of the Installing Contractor of the installation of the UV System if requested by the Owner, including but not limited to:
1. Direct supervision of installation of the UV Reactor, Control Power Panel segments, and interconnecting control/power wiring.
 2. Direct supervision of the Work of the Installing Contractor of the installation of UV System HMI computers (Panel-mounted computers are not to be shipped with the panel).
 3. Verify all field wiring I/O connections made by the Installing Contractor.
 4. Inspect, test and verify all communications links from the respective CPPs to UV reactors and CPPs to SCCs. Inspect, test and verify all LAN communications connections between the CPP and the communication switches.

5. Installing Contractor shall provide and install anchor bolts, fasteners, washers, and templates needed for installation of UV Equipment. The UV Supplier shall design and locate anchor bolts and submit this information as part of the UV equipment Shop Drawings, calculations and installation instructions submissions.
- D. The UV Supplier shall complete the Manufacturer's Certificate of Proper Installation upon satisfactory installation of the UV System.
- E. Refer to General Conditions specifications for additional requirements.

3.02 FIELD QUALITY CONTROL

A. General:

1. In accordance with Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.
2. UV Supplier shall calibrate instruments, sensors, and meters supplied for testing, including UVT analyzers, UV intensity sensors, and power consumption meters.
3. Provide a qualified field technical representative to assist in Functional and Performance testing at both Hicks WPP and Hooper WPP.
4. Provide a qualified technical representative to provide training of Owner's personnel in conjunction with the Performance test each for Hooper WPP and Hicks WPP.

B. Functional Tests:

1. The UV Supplier shall submit a Functional Test Plan, for approval by Engineer that will demonstrate the full operability of UV System after on-site installation. The test plan shall include but is not limited to the testing the full functionality of the UV System. The test will verify the functions of the UV System as installed. The scope of the Functional Test shall demonstrate that each individual component of the UV System operates as specified and that the UV System operates with the complete treatment plant as specified.
2. The Installing Contractor with assistance from the UV Supplier shall complete all functional testing to the satisfaction of the Engineer and the Owner prior to commencing the Facility Startup. The purpose of the Functional Test shall be to demonstrate the effectiveness of all UV System components and control features in all modes of control. Conduct dry testing first, with a follow-up period of wet testing. Wet testing shall not commence until UV reactor has passed hydrotesting and has been disinfected per Specifications by Installing Contractor. UV Supplier shall identify tests that shall be completed with a dry reactor and those that require wet testing.

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3. Testing shall include:
 - a. Automatic control and modulation of butterfly valves by SCC
 - b. Automatic “start/stop” of UV reactor by SCADA OIU(s) and control system(s).
 - c. Manual “start/stop” of UV reactor by SCADA OIU(s) and control system(s).
 - d. Automatic shutoff and alarms for various failure modes for UV reactor, including but not limited to loss of UVT or flow rate signals, lamp or ballast failure, low water level in reactor, high temperature, and cleaning system failure.
 - e. Monitoring and trending of operating data.
 - f. Monitoring and control from remote workstation.
 - g. Bumpless switchover from normal power to emergency power, and emergency power to normal power.
 - h. UV reactor cleaning system operation.
 - i. Monitoring instruments operation.
 - j. Control functions, both at local system and remote workstation.
 - k. Modifying lamp output to verify UV intensity sensors can detect changes in UV intensity.
 - l. Modifying flow and UVT to verify UV System can modify and maintain adequate UV dose.
 - m. All specified communications and alarms between the CPP and the SCC.
 - n. Confirmation of flow meter operation.
 - o. Harmonics test.
4. Functional Testing is not complete until Functional Test report is submitted and accepted by Engineer.

C. Performance Test:

1. The UV Supplier shall submit a Performance Test Plan for approval by Engineer that will demonstrate the full operability of UV System. The test plan shall include, but is not limited to demonstrating automatic, manual, and local modes of operation of the UV System and continuous operation without the production of off-specification water due to failure of any UV System component.
2. Performance Test shall not commence until after successful completion of Functional Test, approval by Owner/Engineer of Performance Test Plan, and minimum operating time of entire UV System (e.g. lamps, ballasts) at 100 percent power level. UV Supplier shall be responsible for replacing failed components of the UV System during this burn-in period at no additional cost to the Owner. Duration of burn-in period for UV equipment shall be defined by the UV Supplier.

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3. Successful completion shall be defined as 5 calendar days of continuous operation without production of off-specification water as a result of failure of a UV System component and demonstration that UV system meets performance requirements established herein. Downtime resulting from plant's operation, including flow or UVT outside of UV reactor's validated range, will not be counted against criteria of "continuous days of operation.". UV Supplier is responsible for conducting the UV System Performance testing and coordination with Installing Contractor and Owner to ensure no unplanned disruptions to water plant operations occur.
4. Testing shall include:
 - a. An extended period of UV operation including normal starts, stops, and changeover to backup UV reactor.
 - b. For each installed reactor verification of normal and emergency operation without malfunction, for example reactor failure or loss of UVT signal.
 - c. Headloss check, power consumption check, UVT and intensity sensor calibration checks, power factor measurements, lamp output verification, sleeve output verification, and UV System dose check based on UV System control panel readings and calculations. Specifically include:
 - 1) Two UVT analyzer calibration and reading stability check with use of Owner's laboratory spectrophotometer, and prepare documentation on compliance with USEPA UVDGM requirements.
 - 2) Sensor calibration check of supplied/installed duty and reference sensors. Provide calibration ratio for each individual sensor calibration check. Prepare documentation on duty UV sensors' compliance with USEPA UVDGM requirements.
 - 3) Measure 'S₀' at the beginning of Performance Test. Measure 'S' for each lamp in each reactor at end of Performance Test. Calculate S/S₀ for each lamp/sensor. Identify results that are outside of manufacturer expectations.
5. Test Report: UV Supplier shall be responsible for coordination and inclusion in report of data and results required to meet reporting requirements whether raw data is contained in UV Supplier's PLC or plant PLCs or SCADA. As a minimum, results shall be provided as follows:
 - a. Daily tabulated data, provide range and average if applicable, of recorded information.
 - b. Energy:
 - 1) Average and range of energy consumption per day, data provided by Owner.

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- 2) Average energy consumption per volume of net water treated.
- 3) Total and individual current harmonic distortion, up to and including 35th harmonic.
- 4) Power factor tests results showing that the UV reactor maintain a 0.90 or greater power factor throughout the full operating range.
- c. Headloss across each reactor at available flowrate vs validated headloss curve.
- d. Other:
 - 1) Quantity of sleeve cleaning cycles and recommended automatic cleaning wiper cycle frequency for operations.
 - 2) Photographs of clean vs. sleeves in service before and after a cleaning cycle after 24 hours of continuous operation at 100 percent power setting.
 - 3) Complete list of parts replaced and reasons for replacement.
 - 4) Complete list and results of calibration or other maintenance activities performed and reasons.
 - 5) Summary of off-specification occurrences, daily volume and total volume per UV reactor.
- e. Results from offsite lamp output, sleeve transmittance, and UV intensity sensor verifications.
6. Performance Testing is not complete until this report is submitted and approved by Engineer.
7. In the event there is a functional failure of the UV equipment during Performance Testing, the contractor shall perform Functional Testing again, to prove the system is functional and then do the Performance Testing. All additional costs for testing will be borne by the UV Supplier.
8. Test for harmonic content at input terminals of each power distribution center. Confirm that the individual and total current and voltage harmonic distortion does not exceed the limits specified or the IEEE 519 limits. Submit documentation of test results. Performance test result to include the measured total and individual current harmonic distortion, up to and including 35th harmonic.

D. Start-up of Unit Processes and Acceptance Testing

1. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and performance testing requirements specified.
2. UV System will be operated by the Contractor and Owner under normal operating conditions for a period of one month (30 days), as defined in Section 01 91 14, Equipment Testing and Facility Startup.

3. During this 30-day Acceptance Test period, the following shall be documented:
 - a. Weekly UVT analyzer accuracy reports shall be provided.
 - b. UV intensity sensor report at start and end of Acceptance Test.
 - c. UV intensity and dose calculation report at start of test and at end of test.
 - d. Lamp fouling observations and report over the 30-day test period.
 - e. Power consumption report over the 30-day test period.
 - f. Manual and auto controls interlock check.
 - g. Operation on backup generator check.
4. UV System Supplier is responsible for addressing the UV equipment failures as defined herein during this time period at UV Supplier's expense.
5. Any failure of a UV system component that results in production of off-specification water shall be considered a failure of the acceptance test. The failure shall be corrected by the Contractor and the Acceptance Test shall start from beginning again.
6. Operator training may be provided during this time period.

E. Operator Training

1. General:
 - a. Training shall not commence until accepted detailed lesson plan for each training activity has been reviewed by Owner.
 - b. Provide for training of designated Owner's personnel in operation and maintenance of UV system.
 - c. Training shall consist of both classroom and hands-on sessions conducted at time and location acceptable to Owner.
 - d. Designate a person responsible for scheduling and coordinating training.
 - e. Training sessions may be recorded if Owner so chooses.
2. Manufacturer's personnel shall provide detailed system training including, as a minimum, the following:
 - a. System operations philosophy.
 - b. System Control:
 - 1) Loop Functions: Understanding loop functions, including interlocks.
 - 2) Loop Operation: For example, adjusting process variable setpoints, and control, and annunciator acknowledgment and resetting.
 - 3) Interfaces with other loops and subsystems.
 - c. Operator interface/system setpoints.
 - d. Component performance requirements.
 - e. Component functions.

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- f. Component maintenance.
 - g. Component troubleshooting.
 - h. Instrument operation, maintenance, troubleshooting, replacement, and calibration procedures.
3. Coordinate training periods with Owner’s operating personnel and manufacturer’s representatives, and with submittal of O&M Manuals.
- a. Initial training shall be completed in conjunction with Functional and/or Performance Testing periods. Additional training may be requested by Owner at additional cost.
 - b. Operation and Maintenance Manuals shall be reviewed, accepted, and resubmitted in accordance with this section before start of training. Modifications resulting from startup of facility shall be incorporated into final manuals.

3.03 SUPPLEMENTS

- A. Supplements listed below, following “End of Section,” are part of this Specification.
- 1. Trojan UV Quote – Hicks WPP.
 - 2. Trojan UV Quote – Hooper WPP.

END OF SECTION



SCOPE OF SUPPLY – CLAYTON COUNTY WATER AUTHORITY – HOOPER WPP, GA – TROJANUVFLEX™ 100 SYSTEM

Prepared for: Jacobs

Specification Section: 46 66 20

Trojan Quote: 231066 (June 2, 2022)

Design Criteria:

Current Peak Design Flow:	22.0 MGD
Average Flow:	14.0 MGD
Minimum Flow:	11.6 MGD
UV Transmission:	90% (minimum) at 22 MGD peak flow
Average Turbidity:	0.06 NTU
Design UV Dose:	2.5-Log <i>Cryptosporidium</i> inactivation 2.5-Log <i>Giardia</i> inactivation
Redundancy:	100% (1 Duty UV reactor and 1 Redundant UV reactor)

We are pleased to submit the following scope of equipment based on the above criteria.

The purchaser is responsible for reading all information contained in this Supply Contract. Trojan will not be held accountable for the supply of equipment not specifically detailed in this document. Detailed installation instructions are provided with the shop drawings and are available earlier upon request. Changes to this Scope of Supply that affect selling price will be handled through a change order.

Please refer inquiries to Trojan Manufacturer's Representative:

Representative: Templeton & Associates
Jordan Longoria
Phone: 470-345-4012
Email: jordan@templeton-associates.com

This proposal has been respectfully submitted by,
Trojan Technologies

Michael Shortt
Regional Manager

ULTRAVIOLET CHAMBER

Trojan's Responsibility:

The ultraviolet chamber will be supplied with all necessary internal equipment such as UV lamps, sleeve wiping system, quartz sleeves, intensity sensors, high temperature switch, air vent valves, and level sensor. The UV lamps and intensity sensors will be packaged separately and will be installed by a Trojan service representative upon start-up.

Chamber Model:	TrojanUVFlex™ 100
Total Number of Chambers:	Two (2)
Chamber Configuration:	Horizontal UV chambers, with horizontal lamp removal
Number of Banks per Chamber:	One (1) bank per UV chamber, each with two (2) sections fully populated
Number of Lamps Per Chamber:	Thirty-two (32)
Number of Sleeves Per Chamber:	Thirty-two (32)
Material of Construction:	2205 Duplex Stainless Steel
Inlet/Outlet Connection:	36" AWWA Class D
Maximum Operating Pressure:	125 psi
UV Intensity Sensors per Chamber:	One (1) Dual-Headed AccUVSensor™
Chamber Weight (approx.), Dry:	2754 lbs

Installation Contractor's Responsibility:

The Installation Contractor is solely responsible for lifting, loading, placement, installation and support of the UV chambers into the building and onto the concrete equipment pad (final location) and any and all costs associated with installation including but not limited to any required temporary or permanent modifications and/or repairs to any new or existing building or structure including all material, labor, engineering and other required services.

The Installation Contractor is responsible for the installation and connection of the following at each of the UV Chambers:

1. Two (2) 24VDC, M12 5-conductor shielded cables (provided by Trojan) from the CPP for the temperature and level switches
2. One (1) 24VDC, M8 5-conductor shielded cables (provided by Trojan) from the CPP for the UV intensity sensors (2 sensors per cable)
3. Thirty-two (32), 4-conductor #14 AWG SOLO Lamp™ cables (provided by Trojan) from the CPP to the Chamber
4. One (1) #10 AWG from the CPP for bonding (by Trojan)

Associated Equipment to be supplied and installed by others:

- Downstream and upstream isolation valves - as required
- All pipe spools, elbows, reducers, etc.
- Flow meter
- Drain valves - as required
- All bolts and gaskets as required for mounting and installation
- Cable wire tray and associated installation for all cables and hydraulic hoses.

LAMP DISTRIBUTION PANEL (LDP)

Trojan's Responsibility:

Lamp Distribution Panel (LDP) shall be supplied with each UV chamber. LDP panels are mounted on UV chamber. The TROJANUVFLEX 100 Lamp Distribution Panel (LDP) is classified as a Power Distribution Center (PDC).

Quantity:	One (1) LDP per UV chamber
Panel Size (W x H x D):	23" X 9" X 23"
Enclosure Material / Rating:	304 Stainless Steel (Type 4X)
Approximate Weight:	120 lbs

CONTROL POWER PANEL (CPP)

Trojan's Responsibility:

The CPP houses both the lamp drivers required to power the lamps in a chamber as well as an interface and microcontroller to monitor and control each UV chamber.

Quantity:	One (1) Single-Door CPP per UV chamber
Enclosure Material / Rating:	304 Stainless Steel (Type 4X, IP66)
Approximate Dimensions (W x H x D):	46" X 85" X 32"
Number of Drivers Installed per CPP:	Eight (8)
Controller Type:	Trojan Microcontroller - Wago
Operator Interface:	7" Beijer HMI
Panel Cooling Method:	Air Conditioner
Panel Surge Protection:	TVSS
Approximate Weight:	1200 lbs
Lamp and I/O Cables:	Trojan to supply all lamp cables, with connectors between the Chamber and CPP

Installation Contractor's Responsibility:

The Installation Contractor is responsible for indoor installation of the CPP as indicated on the drawings. The Installation Contractor is also responsible for the supply, installation and connection of the following at each CPP:

1. One (1) 480V, 60 Hz, 3 phase, 4 wire + GND, 21.7 kVA power feed with local disconnect
 2. Thirty-two (32), 4-conductor #14 AWG SOLO Lamp cables (provided by Trojan) from UV chamber
 3. Two (2) 24VDC, M12 5-conductor cables (provided by Trojan) from the CPP for the temperature and level switch
 4. Two (2) 24VDC, M8 5-conductor cables (provided by Trojan) from the CPP for the UV intensity sensors
 5. One (1) 4-20 mA analog shielded twisted pair from the train flowmeter (by others)
 6. One (1) Belden 3106A #22 AWG shielded twisted pair between CPP panel and associated HSC panel
 7. One (1) Ethernet/IP CAT 5E communication cable from each CPP to the SCC
 8. One (1) #10 AWG (by Trojan) from UV chamber for bonding at each CPP
- ***All conductors, conduit and local disconnects are the responsibility of the CONTRACTOR unless explicitly stated otherwise.***

HYDRAULIC SYSTEM CENTER

Trojan's Responsibility:

The Hydraulic System Center (HSC) houses the equipment required to operate the quartz sleeve cleaning system.

Quantity:	One (1) HSC per UV chamber
Panel Size (W x H x D):	27" x 47" x 21"
Enclosure Material / Rating:	304 Stainless Steel (Type 4X, IP66)
Panel Weight (approx.):	500 lbs
Hydraulic Fluid:	Synthetic Oil

Installation Contractor's Responsibility:

The Installation Contractor is responsible for setting in place and bolting the HSCs as shown on the Trojan drawings. The HSCs must be located within 45 ft of the chamber. The Installation Contractor is also responsible for the supply, connection and installation of the following at each HSC:

1. One (1) 480V, 3 phase, 3 wire + GND, 60 Hz, 2.5 kVA electrical supply
2. One (1) bond link to plant ground, in accordance with applicable codes and standards
3. One (1) Belden 3106A #22 AWG shielded twisted pair between HSC panel and CPP panel
4. Cut and crimp hydraulic hoses (coordination with Parker Store) (hoses and connections supplied by Trojan)
5. Connection of the hydraulic hoses, total of four (4) per UV chamber

SYSTEM CONTROL CENTER

Trojan's Responsibility:

A System Control Center (SCC) will be supplied to monitor and control the UV disinfection System. Trojan will provide a PLC I/O and soft address map to aid the Installation Contractor with integration of the UV PLC and SCADA system.

Note: Trojan will provide the managed Hirschmann BRS20-8TX/2FX switch in the SCC, however the Plant's IT department or System Integrator will be responsible for configuring the switch to meet the Plant's security and traffic routing requirements.

The UV SCC shall consist of the following:

Quantity Supplied:	One (1) SCC
Location:	Wall Mounted (by Installation Contractor)
Controller Type:	CompactLogix
Operator Interface:	10" AB PanelView Plus HMI (Indoor Rated)
Material / Rating:	304 Stainless Steel (Type 4X, IP 66)
Approximate Dimensions (W x H x D):	30" X 36" X 12"
Approximate Weight:	200 lbs
SCADA Protocol:	EtherNet/IP
Surge Protection:	TVSS
Panel UPS:	15 minutes at 24 VDC

Installation Contractor's Responsibility:

The Installation Contractor is responsible for mounting the SCC as indicated on the drawings. Unless otherwise indicated, the Installation Contractor to be responsible for the supply, installation and connection of the following at the SCC:

1. One (1) 120V, 60 Hz, 1 Phase, 2 Wire + GND, 1.8kVA (minimum) power feed
2. One (1) bond link to plant ground, in accordance with applicable codes and standards
3. One (1) Ethernet/IP CAT 5E communication cable from each CPP to the SCC
4. One (1) Fiber Optic communication link to SCADA from SCC

SPARE PARTS AND SAFETY EQUIPMENT

Trojan's Responsibility:

The following spare parts and safety equipment will be supplied with the UV system:

<u>Description</u>	<u>Quantity</u>
500 W UV Solo Lamp	Sixteen (16)
Quartz Sleeves	Sixteen (16)
Ballasts	Two (2)
Ballast Cooling Fans	Two (2)
Lamp Cables	Two (2)
Hose Assy	Two (2)
Duty UVI Sensor	One (1)
Reference UVI Sensor	Three (3)
Wiper Seal	Sixteen (16)
Sleeve O-rings	Sixteen (16)
PLC spare parts (for CPP, HSC and SCC)	One (1) set
Hirschmann Ethernet Switch	One (1)
Operators Kit	One (1)
Face shield	One (1)
SST Equipment Nameplates	One (1) set
316 SST Anchor Bolts	One (1) set

PERFORMANCE TESTING

Trojan's Responsibility:

Trojan will supply a performance testing protocols (Power Consumption, Harmonics and Headloss) to the Installation Contractor to be forwarded to the Engineer for approval. Trojan will produce the final test report and will forward the final report to the Installation Contractor. Trojan will also provide the services of a certified technician for assisting the Installation Contractor in final performance testing, for up to five (5) days.

Installation Contractor's Responsibility:

The Installation Contractor is to cover all associated onsite costs for performance testing (independent lab services if required, i.e. bottles, shipment, etc. in case of microbial testing, ...). The Installation Contractor is also responsible for providing on-site support during the performance testing.

NOTES AND CLARIFICATIONS TO SPECIFICATION

- **Section 46 66 20, 1.03 A.4** – UVT analyzer is currently not included in Trojan's Scope of Supply and shall be provided by others if required.
- **Section 46 66 20, 1.05 A.1.f.** – In lieu of a graph or table for min/max RED as a function of flow, UVT, S/So, and ballast intensity, Trojan provides "Dose Calculation" in UV Submittal package that shows the calculated UV dose for the system based on the design criteria conditions.
- **Section 46 66 20, 1.02 A.2.i, 1.05 A.2.3., 2.06 A.5** – Print out of the UV program cannot be provided. Trojan PLC programs are fully password protected therefore releasing of the software codes should adhere to Trojan's policies and procedure.
- **Section 46 66 20, 2.06 B.1** – Section 40 99 90, Package Control Systems (PCS), is not provided for Trojan review as such Trojan's control panels as included in this Scope of Supply will be Trojan's standard design and will not comply with detailed customizations which might be listed in this section.
- **Section 40 90 01** – It is Trojan's understanding that section 40 90 01, Instrumentation and Control for Process System, is for the System Integrator and Installation Contractor to follow and comply with. As such requirements of this section do not apply to Trojan manufactured panels.
- **Drawings, Sheet 08-N-601** – The connection between Trojan CPP and SCC would be AB Ethernet/IP and not Modbus as shown on this drawing.

DOCUMENTATION (SHOP DRAWINGS AND O&M MANUALS)

The following documentation will be supplied by Trojan per the following schedule:

- One (1) electronic copy of Trojan Shop Drawing **5 – 6** weeks after acceptance of written purchase order
- One (1) electronic copy of Trojan Standard O&M (per Section 01 78 23) at time of equipment delivery

DELIVERY, START-UP AND TRAINING

- Equipment to be shipped **26 – 28** weeks after approval of Shop Drawings and full release to production.

Installation Contractor's Responsibility:

The Contractor is responsible for:

- Un loading of the components supplied by Trojan, storage of all components, if required in a clean dry environment
- Installing the equipment outlined in the scope of Supply in accordance with contract drawings, Trojan's shop drawings, instructions and installation checklist.
- Supplying all conduits and conductors and components per the sites state regulations and components indicated as supplied by others,
- Completing the Checklist and returned at least two (2) weeks prior to date requested for commissioning.
- Completing the Acceptance Testing per **Section 46 66 20, paragraph 3.02 D** for a period of 30 days.

Trojan's Responsibility:

The following start-up services will be provided by Trojan-certified technicians:

- Up to one (1) day in one (1) trip for equipment offloading inspection
- Up to two (2) days in one (1) trip for installation supervision and support. Additional installation assistance as required by phone or fax. Technical Assistance Center 1-866-388-0488 or tac@trojanuv.com
- Up to six (6) days in two (2) trips for start-up, commissioning (dry & wet tests) of the installed UV equipment and operator training
 - If the Trojan's Certified Service Technician determines the Contractor work is not complete and the start-up cannot be completed in the allotted time a return visit will be scheduled at the Contractors expense.
 - If trainees are not available a return visit will be scheduled at the Contractors expense.
- One (1) day in one (1) trip for additional training post-startup
- Five (5) days in one (1) trip for final Performance testing of UV system
- Up to ten (10) days in two (2) trips for any additional site work (as maybe required) including additional Acceptance testing.

WARRANTY

Trojan will warrant the equipment and parts for 24 months after start-up or 30 months after shipment, whichever comes first. Warranty does not cover labor or consumables. Refer to attached Terms and Conditions for additional details.

- UV lamps shall be warranted for 15,000 hours prorated after 9,000 hours or 36 months after shipment, whichever comes first.
- Ballasts shall be warranted for 10 years, prorated after 1 year.
- Quartz sleeves shall be warranted for 10 years, prorated after 1 year.
- UV Intensity sensors shall be warranted for 5 years, prorated after 1 year.

SELLING PRICE

,\$ 790,150.00 USD (Pricing Valid until December 31, 2022)

- Selling price does not include any duties or taxes that may be applicable.
- Freight included if destination is within North America.
- Incoterms 2002: Ex Works (EXW) or Cost, Insurance and Freight (CIF) to destination or port will apply for all other destinations.

PAYMENT TERMS & INVOICING MILESTONES

Net 45 Days

- 5% upon Shop Drawing Submittal
- 25% upon Shop Drawing Approval
- 60% upon Equipment Delivery to job site
- 10% upon Equipment Acceptance

TERMS & CONDITIONS

Trojan appreciates the opportunity to submit this proposal. Our proposal submitted is subject to and based on our standard terms and conditions, which we have attached as part of our proposal. We respectfully reserve the opportunity to negotiate, fair and reasonable contract terms acceptable to both parties, if we are selected for this project.”



Terms and Conditions of Sale

This document sets forth the Terms & Conditions of Sale for goods manufactured and/or supplied, and services provided, by the seller entity identified on the purchase order ("SELLER") and sold to the original purchaser thereof ("BUYER"). The term "SELLER" includes only SELLER, and none of its affiliates. Unless otherwise specifically stated in a previously-executed written purchase agreement signed by authorized representatives of SELLER and BUYER, these Terms & Conditions of Sale establish the rights, obligations and remedies of SELLER and BUYER which apply to this offer and any resulting order or contract for the sale of SELLER's goods and/or services ("Products").

1. APPLICABLE TERMS & CONDITIONS: These Terms & Conditions of Sale are contained directly and/or by reference in SELLER's proposal, offer, order acknowledgment, packing slip, and/or invoice documents. The first of the following acts constitutes an acceptance of SELLER's offer and not a counteroffer and creates a contract of sale ("Contract") in accordance with these Terms & Conditions of Sale: (i) BUYER's issuance of a purchase order document against SELLER's offer; (ii) acknowledgement of BUYER's order by SELLER; or (iii) commencement of any performance by SELLER pursuant to BUYER's order. Provisions contained in BUYER's purchase documents (including electronic commerce interfaces) that materially alter, add to, or subtract from the provisions of these Terms & Conditions of Sale are not a part of the Contract.

2. CANCELLATION AND RETURN: The whole or any part of this order may be cancelled only with the prior written consent of SELLER. If SELLER does consent to a cancellation, such consent will be given only upon payment of reasonable cancellation charges in an amount determined by SELLER. In addition, with respect to any Products returned on cancellation, BUYER will pay SELLER's cost of placing the returned Products in a saleable condition, sales expenses incurred by SELLER in connection with such returned Products, a reasonable restocking charge and freight costs incurred in connection with the original shipment and in connection with returning such Products to SELLER, all in such amounts as are advised to the BUYER by SELLER.

3. DELIVERY: Delivery will be accomplished EXW or CIP at the point of shipment (Incoterms 2020), unless otherwise expressly agreed between the parties. Legal title and risk of loss or damage pass to BUYER upon transfer to the first carrier, regardless of final destination and mode of transit. SELLER will use commercially reasonable efforts to deliver the Products ordered herein within SELLER's normal lead-time necessary for SELLER to deliver the Products sold hereunder. Products will be boxed or crated as determined appropriate by SELLER for protection against normal handling and there will be an extra charge to the BUYER for additional packaging required by the BUYER with respect to waterproofing or other added protection. BUYER has sole responsibility for off-loading, storage and handling of the Products at the site. Where Buyer is responsible for any delay in the delivery date or installation date, the earlier of the date of delivery or the date on which the Products are ready for shipment by SELLER may be treated as the delivery date for purposes of determining the time of payment of the purchase price. Moreover, BUYER will be responsible for reasonable storage and insurance expenses with respect to such Products. Should BUYER fail to effect pick-up of Product as previously agreed in a timely manner, SELLER may, at its discretion, assess reasonable storage charges to the account of BUYER.

4. INSPECTION: BUYER will promptly inspect and accept any Products delivered pursuant to this Contract after receipt of such Products. In the event the Products do not conform to any applicable specifications, BUYER will promptly notify SELLER of such nonconformance in writing. SELLER will have a reasonable opportunity to repair or replace the nonconforming Product at its option. BUYER will be deemed to have accepted any Products delivered hereunder and to have waived any such nonconformance for such Products unless a written notification pursuant to this paragraph is received by SELLER within thirty (30) days of delivery to BUYER destination on order.

5. PRICES & ORDER SIZES: Prices do not include any charges for services such as insurance; brokerage fees; sales, use, inventory, or excise taxes; import or export duties; special financing fees; value added tax, income, or royalty taxes imposed outside the U.S. or Canada; consular fees; special permits or licenses; or other charges imposed upon the production, sale, distribution, or delivery of Products. BUYER will either pay any and all such charges or provide SELLER with acceptable exemption certificates, which obligation survives performance under this Contract. Installation, maintenance and any other services which relate to the Products are not included unless specifically set forth in the quotation. SELLER reserves the right to establish minimum order sizes and will advise BUYER accordingly. Any orders below the minimum order size are subject to a fee as set out by SELLER. If SELLER's delivery of Products surpasses one (1) year in length, then at least on an annual basis, or if changes to the Products are requested or needed, the parties shall conduct good faith discussions regarding changes to the prices for the Products, to reflect SELLER's increased costs for which SELLER shall be entitled to additional fair and appropriate compensation.

6. PAYMENTS: All payments must be made in agreed-to currency, normally Canadian or U.S. Dollars. Unless other payment terms are expressly set forth in the purchase order or otherwise required by the Seller, invoices are due and payable NET 30 DAYS from date of the invoice, without regard to delays for inspection or transportation, with payments to be made by check to SELLER at the address listed in the purchase order or by bank transfer to the account obtainable from SELLER's Accounts Receivable Manager. In the event payments are not made or not made in a timely manner, SELLER may, in addition to all other remedies provided at law, either: (a) declare BUYER's performance in breach and terminate this Contract for default; (b) withhold future shipments until delinquent payments are made; (c) deliver future shipments on a cash-with-order or cash-in-advance basis even after the delinquency is cured; (d) charge interest on the outstanding balance at a rate of 1.5% per month or the maximum rate permitted by law, if lower, for each month or part thereof that there is an outstanding balance plus applicable storage charges and/or inventory carrying charges; (e) repossess the Products for which payment has not been made; (f) pursue other collection efforts and recover all associated costs including reasonable attorney's fees; or (g) combine any of the above rights and remedies as is practicable and permitted by law. BUYER is prohibited from setting off any and all monies owed under this Contract from any other sums, whether liquidated or not, that are or may be due to the BUYER, which arise out of a different transaction with SELLER or any of its affiliates. Should BUYER's financial condition become unsatisfactory to SELLER in its discretion, SELLER may require payment in advance or other security. If BUYER fails to meet these requirements, SELLER may treat such failure as reasonable grounds for repudiation of this Contract, in which case reasonable cancellation charges shall be due to SELLER. BUYER hereby grants SELLER a security interest in the Products, wherever located, and whether now existing or hereafter arising or acquired from time to time, and in all accessions thereto and replacements or modifications thereof, as well as all proceeds of the foregoing, to secure payment in full of all amounts to Seller, which payment releases the security interest but only if such payment could not be considered an avoidable transfer under applicable laws. The security interest granted hereby constitutes a purchase money security interest under the applicable Uniform Commercial Code or Personal Property Security Act or other applicable law, and SELLER is authorized to make whatever registration or notification or take such other action as SELLER deems necessary or desirable to perfect such security interest. BUYER's insolvency, bankruptcy, assignment for the benefit of creditors, or dissolution or termination of the existence of BUYER, constitutes a default under this Contract and affords SELLER all of the remedies of a secured creditor under applicable law, as well as the remedies stated above for late payment or non-payment.

7. LIMITED WARRANTY: Unless specifically provided otherwise in SELLER's quotation, SELLER provides the following Limited Warranty. SELLER warrants that Products sold hereunder will be free from defects in material and workmanship and will, when used in accordance with the manufacturer's operating and maintenance instructions, conform to any express written warranty pertaining to the specific goods purchased, which for Products is for a period of twelve (12) months from delivery. SELLER warrants that services furnished hereunder will be free from defects in workmanship for a period of ninety (90) days from the completion of the services. Products repaired or replaced are not covered by any warranty except to the extent repaired or replaced by SELLER, an authorized representative of SELLER, or under specific instructions by SELLER, in which cases, the Products will be covered under warranty up to the end of the warranty period applicable to the original Products. The above warranties do not include the cost of shipping and handling of returned items. Parts provided by SELLER in the performance of services may be new or refurbished parts functioning equivalent to new parts. Any non-functioning parts that are repaired by SELLER shall become the property of SELLER. No warranties are extended to consumable items such as, without limitation, light bulbs, and for normal wear and tear. All other guarantees, warranties, conditions and representations, either express or implied, whether arising under any statute, law, commercial usage or otherwise, including implied warranties of merchantability and fitness for a particular purpose, are hereby excluded. The sole remedy for Products not meeting this Limited Warranty is replacement, credit or refund of the purchase price, as determined by SELLER in its sole discretion. This remedy will not be deemed to have failed of its essential purpose so long as SELLER is willing to provide such replacement, credit or refund. To make a warranty claim, BUYER must notify SELLER in writing within 5 days of discovery of the defect in question. This notification must include a description of the problem, a copy of the applicable operator's log, a copy of BUYER's maintenance record and any analytical results detailing the problem. Any warranty hereunder or performance guarantees shall only be enforceable if (a) all equipment is properly installed, inspected regularly, and is in good working order, (b) all operations are consistent with SELLER recommendations, (c) operating conditions at the installation site have not materially changed and remain within anticipated specifications, and (d) no reasonably unforeseeable circumstances exist or arise.

8. INDEMNIFICATION: Indemnification applies to a party and to such party's successors-in-interest, assignees, affiliates, directors, officers, and employees ("Indemnified Parties"). SELLER is responsible for and will defend, indemnify and hold harmless the BUYER Indemnified Parties against all losses, claims, expenses or damages which may result from accident, injury, damage, or death due to SELLER's breach of the Limited Warranty. BUYER is responsible for and will defend, indemnify and hold harmless SELLER Indemnified Parties against all losses, claims, expenses, or damages which may result from accident, injury, damage, or death due to the negligence or misuse or misapplication of any Products or the breach of any provision of this Contract by the BUYER or any third party affiliated or in privity with BUYER.

9. PATENT PROTECTION: Subject to all limitations of liability provided herein, SELLER will, with respect to any Products of SELLER's design or manufacture, indemnify BUYER from any and all damages and costs as finally determined by a court of competent jurisdiction in any suit for infringement of any U.S. or Canadian patent (or European patent for Products that SELLER sells to BUYER for end use in a member state of the E.U.) that has issued as of the delivery date, solely by reason of the sale or normal use of any Products sold to BUYER hereunder and from reasonable expenses incurred by BUYER in defense of such suit if SELLER does not undertake the defense thereof, provided that BUYER promptly notifies SELLER of such suit and offers SELLER either (i) full and exclusive control of the defense of such suit when Products of SELLER only are involved, or (ii) the right to participate in the defense of such suit when products other than those of SELLER are also involved. SELLER's warranty as to use patents only applies to infringement arising solely out of the inherent operation of the Products according to their applications as envisioned by SELLER's specifications. In case the Products are in such suit held to constitute infringement and the use of the Products is enjoined, SELLER will, at its own expense and at its option, either procure for BUYER the right to continue using such Products or replace them with non-infringing products, or modify them so they become non-infringing, or remove the Products and refund the purchase price (prorated for depreciation) and the transportation costs thereof. The foregoing states the entire liability of SELLER for patent

infringement by the Products. Further, to the same extent as set forth in SELLER's above obligation to BUYER, BUYER agrees to defend, indemnify and hold harmless SELLER for patent infringement related to (x) any goods manufactured to the BUYER's design, (y) services provided in accordance with the BUYER's instructions, or (z) SELLER's Products when used in combination with any other devices, parts or software not provided by SELLER hereunder.

10. TRADEMARKS AND OTHER LABELS: BUYER agrees not to remove or alter any indicia of manufacturing origin or patent numbers contained on or within the Products, including without limitation the serial numbers or trademarks on nameplates or cast, molded or machined components.

11. SOFTWARE AND INTELLECTUAL PROPERTY: All licenses to SELLER's separately provided software products are subject to the separate software license agreement(s) accompanying the software media. In the absence of such express licenses and for all other software, SELLER grants BUYER only a personal, non-exclusive license to access and use the software provided by SELLER with Products purchased hereunder solely as necessary for BUYER to enjoy the benefit of the Products. A portion of the software may contain or consist of open source software, which BUYER may use under the terms and conditions of the specific license under which the open source software is distributed. BUYER agrees that it will be bound by all such license agreements. Title to software remains with the applicable licensor(s). All SELLER contributions to the Products, the results of the services, and any other work designed or provided by SELLER hereunder may contain or result in statutory and non-statutory Intellectual Property, including but not limited to patentable subject matter or trade secrets; and all such Intellectual Property remains the sole property of SELLER; and BUYER shall not disclose (except to the extent inherently necessary during any resale of Product sold hereunder), disassemble, decompile, or any results of the Services, or any Products, or otherwise attempt to learn the underlying processes, source code, structure, algorithms, or ideas.

12. PROPRIETARY INFORMATION AND PRIVACY: "Proprietary Information" means any information, technical data, or know-how in whatever form, whether documented, contained in machine readable or physical components, mask works or artwork, or otherwise, which SELLER considers proprietary, including but not limited to service and maintenance manuals. BUYER and its customers, employees, and agents will keep confidential all such Proprietary Information obtained directly or indirectly from SELLER and will not transfer or disclose it without SELLER's prior written consent, or use it for the manufacture, procurement, servicing, or calibration of Products or any similar products, or cause such products to be manufactured, serviced, or calibrated by or procured from any other source, or reproduce or otherwise appropriate it. All such Proprietary Information remains SELLER's property. No right or license is granted to BUYER or its customers, employees or agents, expressly or by implication, with respect to the Proprietary Information or any patent right or other proprietary right of SELLER, except for the limited use licenses implied by law. In respect of personal data supplied by BUYER to SELLER, BUYER warrants that is duly authorized to submit and disclose these data, including but not limited to obtaining data subjects' informed consent. SELLER will manage BUYER's information and personal data in accordance with its Privacy Policy, a copy of which is available to Buyer upon request. In respect of other data and information that SELLER may receive in connection with BUYER's use of the Products including without limitation data that are captured by the Products and transmitted to SELLER, BUYER hereby grants SELLER a non-exclusive, worldwide, royalty-free, perpetual, non-revocable license to use, compile, distribute, display, store, process, reproduce, or create derivative works of such data as needed for Product operation and maintenance, and to aggregate such data for use in an anonymous manner, solely to facilitate marketing, sales and R&D activities of SELLER and its affiliates.

13. SPECIAL TOOLS, DIES, JIGS, FIXTURES AND PATTERNS: Any tools, dies, jigs, fixtures, patterns and similar items which are included or required in connection with the manufacture and/or supply of the Products will remain the property of SELLER without credit to the BUYER. SELLER assumes the cost for maintenance and replacement of such items and shall have the right to discard and scrap any such item after it has been inactive for a minimum of one year, without credit to the BUYER.

14. CHANGES AND ADDITIONAL CHARGES: SELLER reserves the right to make design changes or improvements to any products of the same general class as Products being delivered hereunder without liability or obligation to incorporate such changes or improvements to Products ordered by BUYER unless agreed upon in writing before the Products' delivery date.

15. SITE ACCESS / PREPARATION / WORKER SAFETY / ENVIRONMENTAL COMPLIANCE: In connection with services provided by SELLER, BUYER agrees to permit prompt access to equipment. BUYER assumes full responsibility to back-up or otherwise protect its data against loss, damage or destruction before services are performed. BUYER is the operator and in full control of its premises, including those areas where SELLER employees or contractors are performing service, repair, and maintenance activities. BUYER will ensure that all necessary measures are taken for safety and security of working conditions, sites, and installations during the performance of any services. BUYER is the generator of any resulting wastes, including without limitation hazardous wastes. BUYER is solely responsible to arrange for the disposal of any wastes at its own expense. BUYER will, at its own expense, provide SELLER employees and contractors working on BUYER's premises with all information and training required under applicable safety compliance regulations and BUYER's policies. SELLER has no responsibility for the supervision or actions of BUYER's employees or contractors or for non-SELLER items (e.g., chemicals, equipment) and disclaims all liability and responsibility for any loss or damage that may be suffered as a result of such actions or items, or any other actions or items not under SELLER's control.

16. LIMITATIONS ON USE: BUYER will not use any Products for any purpose other than those identified in SELLER's catalogs and literature as intended uses. Unless SELLER has advised the BUYER in writing, in no event will BUYER use any Products in drugs, food additives, food, or cosmetics, or medical applications for humans or animals. In no event will BUYER use in any application any Product that requires FDA 510(k) clearance unless and only to the extent the Product has such clearance. BUYER will not sell, transfer, export, or re-export any SELLER Products or technology for use in activities which involve the design, development, production, use, or stockpiling of nuclear, chemical, or biological weapons or missiles, nor use SELLER Products or technology in any facility which engages in activities relating to such weapons. Unless the "ship-to" address is in California, U.S.A., the Products are not intended for sale in California and may lack markings required by California Proposition 65; accordingly, unless BUYER has ordered Products specifying a California ship-to address, BUYER will not sell or deliver any SELLER Products for use in California. Any warranty granted by SELLER is void if any goods covered by such warranty are used for any purpose not permitted hereunder.

17. EXPORT AND IMPORT LICENSES AND COMPLIANCE WITH LAWS: Unless otherwise expressly agreed, BUYER is responsible for obtaining any required export or import licenses necessary for Product delivery. BUYER will comply with all laws and regulations applicable to the installation or use of all Product, including applicable import and export control laws and regulations of the U.S., E.U., and any other country having proper jurisdiction, and will obtain all necessary export or import licenses in connection with any subsequent export, re-export, transfer, and use of all Product and technology delivered hereunder. BUYER will not sell, transfer, export, or re-export any SELLER Product or technology for use in activities which involve the design, development, production, use or stockpiling of nuclear, chemical, or biological weapons or missiles, nor use SELLER Product or technology in any facility which engages in activities relating to such weapons. BUYER will comply with all local, national, and other laws of all jurisdictions globally relating to anti-corruption, bribery, extortion, kickbacks, or similar matters which are applicable to BUYER's business activities in connection with this Contract, including but not limited to the U.S. Foreign Corrupt Practices Act of 1977, as amended (the "FCPA"). BUYER agrees that no payment of money or provision of anything of value will be offered, promised, paid, or transferred, directly or indirectly, by any person or entity, to any government official, government employee, or employee of any company owned in part by a government, political party, political party official, or candidate for any government office or political party office to induce such organizations or persons to use their authority or influence to obtain or retain an improper business advantage for BUYER or for SELLER, or which otherwise constitute or have the purpose or effect of public or commercial bribery, acceptance of or acquiescence in extortion, kickbacks, or other unlawful or improper means of

obtaining business or any improper advantage, with respect to any of BUYER's activities related to this Contract. SELLER asks BUYER to "Speak Up!" if aware of any violation of law, regulation, or our Code of Conduct ("CoC") in relation to this Contract. See www.danaherintegrity.com and www.danaher.com/how-we-work/integrity-and-compliance for a copy of the CoC and for access to our Helpline portal.

18. RELATIONSHIP OF PARTIES: BUYER is not an agent or representative of SELLER and will not present itself as such under any circumstances, unless and to the extent it has been formally screened by SELLER's compliance department and received a separate duly-authorized letter from SELLER setting forth the scope and limitations of such authorization.

19. FORCE MAJEURE: SELLER is excused from performance of its obligations under this Contract to the extent caused by acts or omissions that are beyond its control, including but not limited to Government embargoes, blockages, seizures or freezing of assets, delays, or refusals to grant an export or import license, or the suspension or revocation thereof, or any other acts of any Government; fires, floods, severe weather conditions, or any other acts of God; quarantines; labor strikes or lockouts; riots; strife; insurrections; civil disobedience or acts of criminals or terrorists; war; material shortages or delays in deliveries to SELLER by third parties. In the event of the existence of any force majeure circumstances, the period of time for delivery, payment terms, and payments under any letters of credit will be extended for a period of time equal to the period of delay. If the force majeure circumstances extend for six months, SELLER may, at its option, terminate this Contract without penalty and without being deemed in default or in breach thereof.

20. NON-ASSIGNMENT AND WAIVER: BUYER will not transfer or assign this Contract or any rights or interests hereunder without SELLER's prior written consent. Failure of either party to insist upon strict performance of any provision of this Contract, or to exercise any right or privilege contained herein, or the waiver of any breach of the terms or conditions of this Contract, will not be construed as thereafter waiving any such terms, conditions, rights, or privileges, and the same will continue and remain in force and effect as if no waiver had occurred.

21. FUNDS TRANSFERS: BUYER and SELLER both recognize that there is a risk of banking fraud when individuals impersonating a business demand payment under new mailing or banking transfer instructions. To avoid this risk, BUYER must verbally confirm any new or changed mailing or banking transfer instructions by calling SELLER and speaking with SELLER's Accounts Receivable Manager before transferring any monies using the new instructions. Both parties agree that they will not institute mailing or banking transfer instruction changes and require immediate payment under the new instructions, but will instead provide a ten (10) day grace period to verify any mailing or banking transfer instruction changes before any new or outstanding payments are due using the new instructions.

22. LIMITATION OF LIABILITY: None of SELLER, its successors-in-interest, assignees, affiliates, directors, officers, and employees will be liable to BUYER under any circumstances for any special, treble, incidental, or consequential damages, including without limitation, damage to or loss of property other than for the Products purchased hereunder; damages incurred in installation, repair, or replacement; lost profits, revenue, or opportunity; loss of use; losses resulting from or related to downtime of the Products or inaccurate measurements or reporting; the cost of substitute products; or claims of BUYER's customers for such damages, howsoever caused, and whether based on warranty, contract, and/or tort (including negligence, strict liability or otherwise). The total liability of SELLER, its successors-in-interest, assignees, affiliates, directors, officers, and employees arising out of the performance or nonperformance hereunder, or SELLER's obligations in connection with the design, manufacture, sale, delivery, and/or use of Products, will in no circumstance exceed the amount actually paid to SELLER for Products delivered hereunder.

23. APPLICABLE LAW AND DISPUTE RESOLUTION: All issues relating to the construction, validity, interpretation, enforcement, and performance of this agreement and the rights and obligations of SELLER and the BUYER hereunder shall be governed by the laws of the Province of Ontario and the federal laws of Canada applicable therein. Any provisions of the International Sale of Goods Act or any convention on contracts for the international sale of goods shall not be applicable to this agreement. The parties submit to and consent to the non-exclusive jurisdiction of courts located in the Province of Ontario.

24. ENTIRE AGREEMENT & MODIFICATION: These Terms & Conditions of Sale constitute the entire agreement between the parties and supersede any prior agreements or representations, whether oral or written. No change to or modification of these Terms & Conditions shall be binding upon SELLER unless in a written instrument specifically referencing that it is amending these Terms & Conditions of Sale and signed by an authorized representative of SELLER. SELLER rejects any additional or inconsistent Terms & Conditions of Sale offered by BUYER at any time, whether or not such terms or conditions materially alter the Terms & Conditions herein and irrespective of SELLER's acceptance of BUYER's order for the described goods and services.

Terms and Conditions Covering Sales of Configured-to-Order Projects and Systems

In addition to all terms and conditions above, the following sections apply to sales of Configured-to-Order Projects, Systems, and the like:

101. PAYMENT.

101.1 Payments will be made per the schedule of payment events set forth in Seller's Quotation; provided that if the Start-Up Date (as defined below) is less than 30 days after the Acceptance Date, 90% of the purchase price is due on or before the Start-Up Date.

101.2. In the event that achievement of a scheduled payment event is delayed or suspended due to the Buyer's convenience or other reasons for which the Buyer or its representatives is responsible, such payment event will be deemed to have occurred and Seller shall be entitled to invoice Buyer as if achievement of such payment event had been achieved. In such circumstances, Buyer must notify Seller in writing of the reasons for the delay and anticipated duration of the delay. Seller will mark the Products (or parts thereof) as the Buyer's property and shall store the Products (or parts thereof) in a segregated area until actual delivery.

102. DELIVERY

102.1 SELLER will request the BUYER to provide a firm date for delivery of the Products to the project site (the "Delivery Date") which SELLER will then use to establish the production schedule for the Products. The Delivery Date will then be binding on the BUYER except for any changes made in accordance with the provisions below.

102.2 The BUYER can request a rescheduling of the Delivery Date on one occasion only by notifying SELLER in writing not less than four weeks prior to the scheduled Delivery Date. The BUYER may request that the Delivery Date be extended by a period up to six weeks, without penalty, but may not request that the Delivery Date be moved forward. The BUYER may also request that the Delivery Date be extended beyond a six-week period but, SELLER may not agree to such extension, beyond the maximum six-week extension period

102.3 SELLER may, in its sole discretion, agree to change the Delivery Date on more than one occasion or if less than four weeks' prior notice is provided of a requested change, but is under no obligation to do so.

102.4 SELLER reserves the right to reschedule the Delivery Date to a date prior to or subsequent to the scheduled Delivery Date in order to accommodate its shipping, production or other requirements. This right to reschedule will be applicable unless otherwise agreed in writing by an authorized officer of SELLER. SELLER will provide the BUYER or its representative with a minimum of 24 hours' notice of any such rescheduling.

102.5 Where any change to the Delivery Date is made at BUYER's request, for all purposes with respect to the warranty and payment provided by SELLER in connection with the Products, the initial Delivery Date will be considered to be the Delivery Date regardless of any change later made to the Delivery Date.

103. ACCEPTANCE

103.1 During the period between the Delivery Date and the Start-up Date, the BUYER shall prepare the Products and the project site for installation and start-up and, unless otherwise agreed in writing by an authorized representative of SELLER, shall complete acceptance testing with respect to the Products. The Products shall be deemed to be accepted on the earliest to occur of the following dates (the "Acceptance Date"): (a) that date on which the Products can function in either manual or automatic operation and provide disinfection in accordance with criteria specified in the Quotation, or (b) 60 days after the Delivery Date.

103.2 All amounts which remain owing by the BUYER for the Products, including any amount which is specified to be payable on the Acceptance Date, will be paid by the BUYER to SELLER within 30 days after the Acceptance Date, unless otherwise agreed in writing by an authorized representative of SELLER.

103.3 Written notification must be given by the BUYER to SELLER within seven days after the Acceptance Date listing any outstanding deficiencies with respect to the Products and SELLER will use all reasonable efforts to correct such deficiencies promptly.

104. START-UP

104.1 SELLER will request a firm date for start-up of the Equipment (the "Start-Up Date"). Trojan will then schedule its technician to be on-site for the Start-up Date. The Start-up Date is binding except for any changes made in accordance with the provisions below.

104.2 On the Start-up Date, BUYER must have the Equipment and site ready as provided in the Installation Preparation Checklist contained in the Contractor Installation Package sent to BUYER and must have paid all amounts then due and payable to SELLER.

104.3 BUYER can request a rescheduling of the Start-up Date by notifying SELLER in writing not less than three weeks prior to the Start-up Date. BUYER may request that the Start-up Date be extended but may not request that the Start-up Date be moved forward. SELLER requires a minimum extension period of two weeks between the existing Start-up Date and the requested new Start-up Date in order to reschedule its technician.

104.4 SELLER may, in its sole discretion, agree to reschedule the Start-up Date where a BUYER requests less than a two-week extension but is under no obligation to do so. In the event that SELLER does agree to less than a two-week extension or that BUYER requests more than two changes to the Start-up Date, BUYER will be charged an administration fee in an amount determined by SELLER.

104.5 SELLER reserves the right to reschedule the Start-up Date to a date which is prior to or subsequent to the scheduled Start-up Date in order to accommodate its resource availability. This right to reschedule will be applicable unless otherwise agreed in writing by an authorized officer of SELLER. SELLER will provide BUYER or its representative with a minimum of 72 hours' notice of any such change to the Start-up Date.

104.6 In the event that SELLER'S technician arrives at the project site and finds that the Equipment or the project site is not ready for start-up as defined in the Contractor Installation Package, or any amounts then due and payable to SELLER remain unpaid, BUYER may either:

(a) provided all amounts then due and payable to SELLER have been paid, issue a purchase order for all costs involved in having SELLER correct the deficiencies, or

(b) have SELLER'S technician leave the site and then reschedule the Start-up Date to a date when all deficiencies will be corrected, and the Equipment will be ready for start-up as defined in the Contractor Installation Package. If BUYER selects this option, the cost of rescheduling will be not less than a minimum amount specified by SELLER, with the final cost being determined by SELLER based on its costs and expenses incurred in connection with the rescheduling.



SCOPE OF SUPPLY – CLAYTON COUNTY WATER AUTHORITY – HICKS WPP, GA – TROJANUVFLEX™ 100 SYSTEM

Prepared for: Jacobs

Specification Section: 46 66 20

Trojan Quote: 227366 (June 2, 2022)

Design Criteria:

Current Peak Design Flow:	10.0 MGD
Average Flow:	5.0 MGD
Minimum Flow:	3.9 MGD
UV Transmission:	90% (minimum) at 10 MGD peak flow
Average Turbidity:	0.04 NTU
Design UV Dose:	2.5-Log <i>Cryptosporidium</i> inactivation 2.5-Log <i>Giardia</i> inactivation
Redundancy:	100% (1 Duty UV reactor and 1 Redundant UV reactor)

We are pleased to submit the following scope of equipment based on the above criteria.

The purchaser is responsible for reading all information contained in this Supply Contract. Trojan will not be held accountable for the supply of equipment not specifically detailed in this document. Detailed installation instructions are provided with the shop drawings and are available earlier upon request. Changes to this Scope of Supply that affect selling price will be handled through a change order.

Please refer inquiries to Trojan Manufacturer's Representative:

Representative: Templeton & Associates
Jordan Longoria
Phone: 470-345-4012
Email: jordan@templeton-associates.com

This proposal has been respectfully submitted by,
Trojan Technologies

Michael Shortt
Regional Manager

ULTRAVIOLET CHAMBER

Trojan's Responsibility:

The ultraviolet chamber will be supplied with all necessary internal equipment such as UV lamps, sleeve wiping system, quartz sleeves, intensity sensors, high temperature switch, air vent valves, and level sensor. The UV lamps and intensity sensors will be packaged separately and will be installed by a Trojan service representative upon start-up.

Chamber Model:	TrojanUVFlex™ 100
Total Number of Chambers:	Two (2)
Chamber Configuration:	Horizontal UV chambers, with horizontal lamp removal
Number of Banks per Chamber:	One (1) bank per UV chamber, each with one (1) section populated
Number of Lamps Per Chamber:	Sixteen (16)
Number of Sleeves Per Chamber:	Sixteen (16)
Material of Construction:	2205 Duplex Stainless Steel
Inlet/Outlet Connection:	36" AWWA Class B
Maximum Operating Pressure:	60 psi
UV Intensity Sensors per Chamber:	One (1) Dual-Headed AccUVSensor™
Chamber Weight (approx.), Dry:	2754 lbs

Installation Contractor's Responsibility:

The Installation Contractor is solely responsible for lifting, loading, placement, installation and support of the UV chambers into the building and onto the concrete equipment pad (final location) and any and all costs associated with installation including but not limited to any required temporary or permanent modifications and/or repairs to any new or existing building or structure including all material, labor, engineering and other required services.

The Installation Contractor is responsible for the installation and connection of the following at each of the UV Chambers:

1. Two (2) 24VDC, M12 5-conductor shielded cables (provided by Trojan) from the CPP for the temperature and level switches
2. One (1) 24VDC, M8 5-conductor shielded cables (provided by Trojan) from the CPP for the UV intensity sensors (2 sensors per cable)
3. Sixteen (16), 4-conductor #14 AWG SOLO Lamp™ cables (provided by Trojan) from the CPP to the Chamber
4. One (1) #10 AWG from the CPP for bonding (by Trojan)

Associated Equipment to be supplied and installed by others:

- Downstream and upstream isolation valves - as required
- All pipe spools, elbows, reducers, etc.
- Flow meter
- Drain valves - as required
- All bolts and gaskets as required for mounting and installation
- Cable wire tray and associated installation for all cables and hydraulic hoses.

LAMP DISTRIBUTION PANEL (LDP)

Trojan's Responsibility:

Lamp Distribution Panel (LDP) shall be supplied with each UV chamber. LDP panels are mounted on UV chamber. The TROJANUVFLEX 100 Lamp Distribution Panel (LDP) is classified as a Power Distribution Center (PDC).

Quantity:	One (1) LDP per UV chamber
Panel Size (W x H x D):	23" X 9" X 23"
Enclosure Material / Rating:	304 Stainless Steel (Type 4X)
Approximate Weight:	120 lbs

CONTROL POWER PANEL (CPP)

Trojan's Responsibility:

The CPP houses both the lamp drivers required to power the lamps in a chamber as well as provides an interface and microcontroller to monitor and control each UV chamber.

Quantity:	One (1) Single-Door CPP per UV chamber
Enclosure Material / Rating:	304 Stainless Steel (Type 4X, IP66)
Approximate Dimensions (W x H x D):	46" X 85" X 32"
Number of Drivers Installed per CPP:	Four (4)
Controller Type:	Trojan Microcontroller - Wago
Operator Interface:	7" Beijer HMI
Panel Cooling Method:	Air Conditioner
Panel Surge Protection:	TVSS
Approximate Weight:	1200 lbs
Lamp and I/O Cables:	Trojan to supply all lamp cables, with connectors between the Chamber and CPP

Installation Contractor's Responsibility:

The Installation Contractor is responsible for indoor installation of the CPP as indicated on the drawings. The Installation Contractor is also responsible for the supply, installation and connection of the following at each CPP:

1. One (1) 480V, 60 Hz, 3 phase, 4 wire + GND, 15.0 kVA power feed with local disconnect
 2. Sixteen (16), 4-conductor #14 AWG SOLO Lamp cables (provided by Trojan) from UV chamber
 3. Two (2) 24VDC, M12 5-conductor cables (provided by Trojan) from the CPP for the temperature and level switch
 4. Two (2) 24VDC, M8 5-conductor cables (provided by Trojan) from the CPP for the UV intensity sensors
 5. One (1) 4-20 mA analog shielded twisted pair from the train flowmeter (by others)
 6. One (1) Belden 3106A #22 AWG shielded twisted pair between CPP panel and associated HSC panel
 7. One (1) Ethernet/IP CAT 5E communication cable from each CPP to the SCC
 8. One (1) #10 AWG (by Trojan) from UV chamber for bonding at each CPP
- ***All conductors, conduit and local disconnects are the responsibility of the CONTRACTOR unless explicitly stated otherwise.***

HYDRAULIC SYSTEM CENTER

Trojan's Responsibility:

The Hydraulic System Center (HSC) houses the equipment required to operate the quartz sleeve cleaning system.

Quantity:	One (1) HSC per UV chamber
Panel Size (W x H x D):	27" x 47" x 21"
Enclosure Material / Rating:	304 Stainless Steel (Type 4X, IP66)
Panel Weight (approx.):	500 lbs
Hydraulic Fluid:	Synthetic Oil

Installation Contractor's Responsibility:

The Installation Contractor is responsible for setting in place and bolting the HSCs as shown on the Trojan drawings. The HSCs must be located within 45 ft of the chamber. The Installation Contractor is also responsible for the supply, connection and installation of the following at each HSC:

1. One (1) 480V, 3 phase, 3 wire + GND, 60 Hz, 2.5 kVA electrical supply
2. One (1) bond link to plant ground, in accordance with applicable codes and standards
3. One (1) Belden 3106A #22 AWG shielded twisted pair between HSC panel and CPP panel
4. Cut and crimp hydraulic hoses (coordination with Parker Store) (hoses and connections supplied by Trojan)
5. Connection of the hydraulic hoses, total of four (4) per UV chamber

SYSTEM CONTROL CENTER

Trojan’s Responsibility:

A System Control Center (SCC) will be supplied to monitor and control the UV disinfection System. Trojan will provide a PLC I/O and soft address map to aid the Installation Contractor with integration of the UV PLC and SCADA system.

Note: Trojan will provide the managed Hirschmann BRS20-8TX/2FX switch in the SCC, however the Plant’s IT department or System Integrator will be responsible for configuring the switch to meet the Plant’s security and traffic routing requirements.

The UV SCC shall consist of the following:

Quantity Supplied:	One (1) SCC
Location:	Wall Mounted (by Installation Contractor)
Controller Type:	CompactLogix
Operator Interface:	10” AB PanelView Plus HMI (Indoor Rated)
Material / Rating:	304 Stainless Steel (Type 4X, IP 66)
Approximate Dimensions (W x H x D):	30” X 36” X 12”
Approximate Weight:	200 lbs
SCADA:	EtherNet/IP
Surge Protection:	TVSS
Panel UPS:	15 minutes at 24 VDC

Installation Contractor’s Responsibility:

The Installation Contractor is responsible for mounting the SCC as indicated on the drawings. Unless otherwise indicated, the Installation Contractor to be responsible for the supply, installation and connection of the following at the SCC:

1. One (1) 120V, 60 Hz, 1 Phase, 2 Wire + GND, 1.8kVA (minimum) power feed
2. One (1) bond link to plant ground, in accordance with applicable codes and standards
3. One (1) Ethernet/IP CAT 5E communication cable from each CPP to the SCC
4. One (1) Fiber Optic communication link to SCADA from SCC

SPARE PARTS AND SAFETY EQUIPMENT

Trojan’s Responsibility:

The following spare parts and safety equipment will be supplied with the UV system:

<u>Description</u>	<u>Quantity</u>
500 W UV Solo Lamp	Eight (8)
Quartz Sleeves	Eight (8)
Ballasts	Two (2)
Ballast Cooling Fans	Two (2)
Lamp Cables	Two (2)
Hose Assy	Two (2)
Duty UVI Sensor	One (1)
Reference UVI Sensor	Three (3)
Wiper Seal	Eight (8)
Sleeve O-rings	Eight (8)
PLC spare parts (for CPP, HSC and SCC)	One (1) set
Hirschmann Ethernet Switch	One (1)
Operators Kit	One (1)
Face shield	One (1)
SST Equipment Nameplates	One (1) set
316 SST Anchor Bolts	One (1) set

PERFORMANCE TESTING

Trojan's Responsibility:

Trojan will supply a performance testing protocols (Power Consumption, Harmonics and Headloss) to the Installation Contractor to be forwarded to the Engineer for approval. Trojan will produce the final test report and will forward the final report to the Installation Contractor. Trojan will also provide the services of a certified technician for assisting the Installation Contractor in final performance testing, for up to five (5) days.

Installation Contractor's Responsibility:

The Installation Contractor is to cover all associated onsite costs for performance testing (independent lab services if required, i.e. bottles, shipment, etc. in case of microbial testing, ...). The Installation Contractor is also responsible for providing on-site support during the performance testing.

NOTES AND CLARIFICATIONS TO SPECIFICATION

- **Section 46 66 20, 1.03 A.4** – UVT analyzer is currently not included in Trojan's Scope of Supply and shall be provided by others if required.
- **Section 46 66 20, 1.05 A.1.f.** – In lieu of a graph or table for min/max RED as a function of flow, UVT, S/So, and ballast intensity, Trojan provides "Dose Calculation" in UV Submittal package that shows the calculated UV dose for the system based on the design criteria conditions.
- **Section 46 66 20, 1.02 A.2.i, 1.05 A.2.3., 2.06 A.5** – Print out of the UV program cannot be provided. Trojan PLC programs are fully password protected therefore releasing of the software codes should adhere to Trojan's policies and procedure.
- **Section 46 66 20, 2.06 B.1** – Section 40 99 90, Package Control Systems (PCS), is not provided for Trojan review as such Trojan's control panels as included in this Scope of Supply will be Trojan's standard design and will not comply with detailed customizations which might be listed in this section.
- **Section 40 90 01** – It is Trojan's understanding that section 40 90 01, Instrumentation and Control for Process System, is for the System Integrator and Installation Contractor to follow and comply with. As such requirements of this section do not apply to Trojan manufactured panels.
- **Drawings, Sheet 08-N-602** – The connection between Trojan CPP and SCC would be AB Ethernet/IP and not Modbus as shown on this drawing.

DOCUMENTATION (SHOP DRAWINGS AND O&M MANUALS)

The following documentation will be supplied by Trojan per the following schedule:

- One (1) electronic copy of Trojan Shop Drawing **5 – 6** weeks after acceptance of written purchase order
- One (1) electronic copy of Trojan Standard O&M (per Section 01 78 23) at time of equipment delivery

DELIVERY, START-UP AND TRAINING

- Equipment to be shipped **26 – 28** weeks after Approval of Shop Drawings and Full Release to Production

Installation Contractor's Responsibility:

The Contractor is responsible for:

- Un loading of the components supplied by Trojan, storage of all components, if required in a clean dry environment
- Installing the equipment outlined in the scope of Supply in accordance with contract drawings, Trojan's shop drawings, instructions and installation checklist.
- Supplying all conduits and conductors and components per the sites state regulations and components indicated as supplied by others,
- Completing the Checklist and returned at least two (2) weeks prior to date requested for commissioning.
- Completing the Acceptance Testing per **Section 46 66 20, paragraph 3.02 D** for a period of 30 days.

Trojan's Responsibility:

The following start-up services will be provided by Trojan-certified technicians:

- Up to one (1) day in one (1) trip for equipment offloading inspection
- Up to two (2) days in one (1) trip for installation supervision and support. Additional installation assistance as required by phone or fax. Technical Assistance Center 1-866-388-0488 or tac@trojanuv.com
- Up to six (6) days in two (2) trips for start-up, commissioning (dry & wet tests) of the installed UV equipment and operator training
 - If the Trojan's Certified Service Technician determines the Contractor work is not complete and the start-up cannot be completed in the allotted time a return visit will be scheduled at the Contractors expense.
 - If trainees are not available a return visit will be scheduled at the Contractors expense.
- One (1) day in one (1) trip for additional training post-startup
- Five (5) days in one (1) trip for final Performance testing of UV system
- Up to ten (10) days in two (2) trips for any additional site work (as maybe required) including additional Acceptance testing.

WARRANTY

Trojan will warrant the equipment and parts for 24 months after start-up or 30 months after shipment, whichever comes first. Warranty does not cover labor or consumables. Refer to attached Terms and Conditions for additional details.

- UV lamps shall be warranted for 15,000 hours prorated after 9,000 hours or 36 months after shipment, whichever comes first.
- Ballasts shall be warranted for 10 years, prorated after 1 year.
- Quartz sleeves shall be warranted for 10 years, prorated after 1 year.
- UV Intensity sensors shall be warranted for 5 years, prorated after 1 year.

SELLING PRICE

\$ 705,200.00 USD (Pricing Valid until December 31, 2022)

- Selling price does not include any duties or taxes that may be applicable.
- Freight included if destination is within North America.
- Incoterms 2002: Ex Works (EXW) or Cost, Insurance and Freight (CIF) to destination or port will apply for all other destinations.

PAYMENT TERMS & INVOICING MILESTONES

Net 45 Days

- 5% upon Shop Drawing Submittal
- 25% upon Shop Drawing Approval
- 60% upon Equipment Delivery to job site
- 10% upon Equipment Acceptance

TERMS & CONDITIONS

Trojan appreciates the opportunity to submit this proposal. Our proposal submitted is subject to and based on our standard terms and conditions, which we have attached as part of our proposal. We respectfully reserve the opportunity to negotiate, fair and reasonable contract terms acceptable to both parties, if we are selected for this project.”

VOLUME 3 OF 3

DRAWINGS
(BOUND SEPARATELY)
