

PROJECT MANUAL

Repairs to the Walt Williams Filtration Plant AND Walt Williams Filtration Plant Filter Rehabilitation

(Project Nos. 36432-10 and 36432-11)



LAGRANGE
G E O R G I A

Volume III of III

**City of LaGrange
LaGrange, Georgia**

JULY 2022

ISSUED FOR BIDS

BARGE
DESIGN SOLUTIONS

Repairs to the Walt Williams Filtration Plant
(Project No. 36432-10)

AND

Walt Williams Filtration Plant Filter Rehabilitation
(Project No. 36432-11)

City of LaGrange
LaGrange, Georgia

The following licensed professionals are responsible for the various portions by which their seal, signature and date is affixed:

- Division 00 – Procurement and Contracting Requirements
- Division 01 - General Requirements
- Division 04 - Masonry
- Division 06 – Wood, Plastics and Composites
- Division 07 – Thermal and Moisture Protection
- Division 08 - Openings
- Division 09 – Finishes



Kerry Osborne, RA

Division 05 – Metals



5/5/2022
Brian Wood, PE

END OF SECTION

Section 00 01 05

Certifications

The following licensed professionals are responsible for the various portions of the Project manual by which their seal, signature and date is affixed:

- Division 00 – Procurement and Contracting Requirements
- Division 01 - General Requirements
- Division 02 - Existing Conditions
- Division 09 – Finishes
- Division 40 - Process Integration



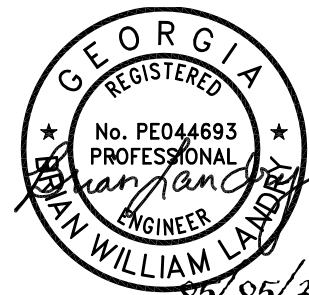
Mike Alexander, PE

- Division 03 - Concrete
- Division 05 – Metals



Brian Wood, PE

- Division 26 – Electrical



Brian Landry, PE

END OF SECTION

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| 00 21 13 | Instructions to Bidders |
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| 00 43 13 | Bid Bond |
| 00 45 13 | Statement of Bidder's Qualifications |
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Part 1 General

1.1 Work Included

- A. Demolition of designated structures, foundations and platforms, mechanical equipment, and electrical equipment.
- B. Unless otherwise noted, remove all demolition material from the project site and properly dispose of all demolition material at a location selected and provided by the Contractor.
- C. As noted, remove and salvage electrical and mechanical equipment and facilities for reuse on this project and/or for delivery to the Owner for Owner's future use.

1.2 Project Description

- A. Demolition Plan
 - 1. Prepare a Demolition Plan and submit proposed salvage, demolition, and removal procedures for approval before work is started. Include in the plan procedures for careful removal and disposition of materials specified to be salvaged, coordination with other work in progress, and a detailed description of methods and equipment to be used for each operation. Plan shall be approved by Engineer prior to work beginning.
 - 2. General Requirements: Do not begin demolition or deconstruction until authorization is received from the Engineer. Remove rubbish and debris from the project site; do not allow accumulations. Store materials that cannot be removed daily in areas specified by the Engineer.

1.3 Items To Remain In Place

- A. Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Owner. Repair or replace damaged items as approved by the Engineer. Coordinate the work of this section with all other work indicated.
- B. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition, deconstruction, or removal work. Repairs, reinforcement, or structural replacement require approval by the Engineer prior to performing such work.
- C. Do not overload pavements to remain.

Demolition

- D. Existing Construction Limits and Protection: Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove dust, dirt, and debris from work areas daily.
- E. 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.
 - 2. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

1.4 Burning

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

1.5 Submittals

- A. Submit the following in accordance with Section [01 33 00 - Submittal Procedures]:
 - 1. Existing Conditions Survey
 - 2. Demolition Plan

1.6 Quality Assurance

- A. Comply with federal, state, and local hauling and disposal regulations.
- B. Use of explosives will not be permitted.
- C. Dust and Debris Control: 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.

1.7 Protection

- A. Protection of Personnel: Before, during and after the demolition work continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the project site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

1.8 Relocations

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

1.9 Existing Conditions

- A. Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the Engineer showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 4 inch by 6 inch or electronic photographs of equivalent resolution will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all required outages which will be required during the course of work, and to note these outages on the record document.
- B. Submit survey results.

Part 2 Products

Not Used

Part 3 Not Execution

3.1 Existing Facilities To Be Removed

- A. Utilities and Related Equipment
 - 1. General Requirements: Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Engineer. Do not begin demolition work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

2. Disconnecting Existing Utilities: Remove existing utilities, as indicated, and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Engineer. When utility lines are encountered but are not indicated on the drawings, notify the Engineer prior to further work in that area. Remove meters, copper piping, and related equipment and deliver to Owner in accordance with instructions of the Engineer.

B. Concrete

1. Saw concrete along straight lines to a depth of a minimum 2 inch. 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. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete.

C. Miscellaneous Metal

1. Salvage shop-fabricated items such as access doors and frames, steel gratings, metal ladders, wire mesh partitions, metal railings, metal windows and similar items as whole units.

D. Patching

1. Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. 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. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish. For concrete and masonry, completely fill holes and depressions, caused by previous physical damage or left as a result of removals in existing masonry walls to remain, with an approved masonry patching material, applied in accordance with the manufacturer's printed instructions.

E. Mechanical Equipment and Fixtures

1. Disconnect mechanical hardware at the nearest connection to existing services to remain, unless otherwise noted. Disconnect mechanical equipment and fixtures at fittings. Remove service valves attached to the unit. Salvage each item of equipment and fixtures as a whole unit; listed, indexed, tagged, and stored. Salvage each unit with its normal operating auxiliary equipment. Transport salvaged equipment and fixtures, including motors and machines, to a designated storage area as directed by the Engineer.
2. Do not remove equipment until approved.

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3. Preparation for Storage: Remove water, dirt, dust, and foreign matter from units; tanks, piping and fixtures shall be drained; interiors, if previously used to store flammable, explosive, or other dangerous liquids, shall be steam cleaned. Seal openings with caps, plates, or plugs. Secure motors attached by flexible connections to the unit. Change lubricating systems with the proper oil or grease.
- F. Piping: Disconnect piping at unions, flanges and valves, and fittings as required to reduce the pipe into straight lengths for practical storage. Store salvaged piping according to size and type. If the piping that remains can become pressurized due to upstream valve failure, end caps, blind flanges, or other types of plugs or fittings with a pressure gage and bleed valve shall be attached to the open end of the pipe to ensure positive leak control. Carefully dismantle piping that previously contained gas, gasoline, oil, or other dangerous fluids, with precautions taken to prevent injury to persons and property. Store piping outdoors until all fumes and residues are removed. Box prefabricated supports, hangers, plates, valves, and specialty items according to size and type. Classify piping not designated for salvage, or not reusable, as scrap metal.
- G. Fixtures, Motors and Machines: Where shown, remove and salvage fixtures, motors and machines associated with plumbing, heating, air conditioning, refrigeration, and other mechanical system installations. Salvage, box and store auxiliary units and accessories with the main motor and machines. Tag salvaged items for identification, storage, and protection from damage.
- H. Electrical Equipment and Fixtures
1. Salvage motors, motor controllers, and operating and control equipment that are attached to the driven equipment. Salvage wiring systems and components. Box loose items and tag for identification. Disconnect primary, secondary, control, communication, and signal circuits at the point of attachment to their distribution system.
 2. Fixtures: Remove and salvage electrical fixtures. Salvage unprotected glassware from the fixture and salvage separately. Salvage incandescent, mercury-vapor, and fluorescent lamps and fluorescent ballasts manufactured prior to 1978, boxed and tagged for identification, and protected from breakage.
 3. Electrical Devices: Remove and salvage switches, switchgear, transformers, conductors including wire and nonmetallic sheathed and flexible armored cable, regulators, meters, instruments, plates, circuit breakers, panelboards, outlet boxes, and similar items. Box and tag these items for identification according to type and size.
 4. Wiring Ducts or Troughs: Remove and salvage wiring ducts or troughs. Dismantle plug-in ducts and wiring troughs into unit lengths. Remove plug-in or disconnecting devices from the busway and store separately.

5. Conduit and Miscellaneous Items: Salvage conduit except where embedded in concrete or masonry. Consider corroded, bent, or damaged conduit as scrap metal. Sort straight and undamaged lengths of conduit according to size and type. Classify supports, knobs, tubes, cleats, and straps as debris to be removed and disposed.

3.2 Disposition of Material

- A. Title to Materials: Except for salvaged items specified in related Sections, and for materials or equipment scheduled for salvage, all materials and equipment removed and not reused or salvaged, shall become the property of the Contractor and shall be removed from Owner's property. Title to materials resulting from demolition, and materials and equipment to be removed, is vested in the Contractor upon approval by the Engineer of the Contractor's demolition and removal procedures, and authorization by the Engineer to begin demolition and deconstruction. The Owner will not be responsible for the condition or loss of, or damage to, such property after contract award. Showing for sale or selling materials and equipment on site is prohibited.
- B. Salvaged Materials and Equipment: Remove materials and equipment that are indicated to be removed by the Contractor and that are to remain the property of the Owner and deliver to a storage site as directed by the Engineer.
 1. Copper pipe removed shall remain the property of the Owner and shall be stockpiled on the water plant site as directed by the Engineer.
 2. Salvage items and material to the maximum extent possible.
 3. Store all materials salvaged for the Contractor as approved by the Engineer and remove from Owner's property before completion of the contract. On site sales of salvaged material is prohibited.
 4. Remove salvaged items to remain the property of the Owner in a manner to prevent damage, and packed or crated to protect the items from damage while in storage or during shipment. Items damaged during removal or storage must be repaired or replaced to match existing items. Properly identify the contents of containers. Deliver the following items reserved as property of the Owner to the areas designated by the City of LaGrange.
- C. Unsalvageable and Non-Recyclable Material: Dispose of unsalvageable and non-recyclable noncombustible material off-site in accordance with appropriate regulations.
- D. Existing Filter Media: filter media, including sand and anthracite, will be hauled to and disposed of at the City's landfill site. The City will arrange for no tipping fees to be charges or pay for all tipping fees.

3.3 Cleanup

- A. Remove debris and rubbish. Remove and transport the debris in a manner that prevents spillage on streets or adjacent areas. Apply local regulations regarding hauling and disposal.

3.4 Disposal of Removed Materials

- A. Regulation of Removed Materials: Dispose of debris, rubbish, scrap, and other non-salvageable materials resulting from removal operations in accordance with all applicable federal, state and local regulations.
- B. Removal from Owner's Property: Transport waste materials removed from demolished and deconstructed structures, except waste soil, from Owner's property for legal disposal. Dispose of waste soil as directed.

3.5 Reuse of Salvaged Items

- A. Recondition salvaged materials and equipment designated for reuse before installation. Replace items damaged during removal and salvage operations or restore them as necessary to usable condition.

END OF SECTION

Part 1 General

1.1 Summary

- A. Requirements for furnishing all labor, material and equipment for the rehabilitation and/or protection of concrete surfaces by application of a coating system suitable for a waste treatment environment. The protective coatings shall eliminate infiltration, repair voids, and enhance structural integrity of the structure.

1.2 References

- A. ASTM International (ASTM)
 - 1. ASTM C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
 - 2. ASTM D4258 - Practice for Surface Cleaning Concrete for Coating.
 - 3. ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
 - 4. ASTM D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
- B. International Concrete Repair Institute (ICRI)
 - 1. Technical Guideline No. 310.1R-2008 (formally 03730) - Guide for Surface Preparation for Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.
 - 2. Technical Guideline No. 310.2-2008 (formally 03732) - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Overlays.
 - 3. Technical Guideline No. 320.1R-2019 (formally 03731) - Guide for Selecting Application Methods for the Repair of Concrete Surfaces.
- C. SSPC - The published Standards of the Society of Protective Coatings.
- D. NACE - The published standards of the National Association of Corrosion Engineers.

1.3 Submittals

- A. Submit in accordance with Section 01 33 23.
- B. Product Data:
 - 1. Description, layout, and application sequencing plan.

2. Rehabilitation system application requirements including material handling and storage requirements, mixing and proportioning requirements (as applicable), maximum pot life, film/coating thickness, curing testing and certification requirements of all rehabilitation materials, Product Material Safety Data Sheets (MSDS).
 3. Testing procedures and quality control procedures.
 4. ASTM test results indicating that the product conforms to and is suitable for its intended use per these specifications
- C. Warranty Certificate in accordance with Article 1.7 of this specification.
- D. Provide reference documentation that the proposed coating system has a proven performance record when used in the intended application, including a list of five (5) successful installations that have been in service for a minimum of ten (10) years. The reference listing shall include the name, date, location of the installation, and a contact name and telephone number.
- E. Applicator Qualifications
1. Manufacturer's certification that the applicator has been trained and approved in the handling, mixing and application of each product used.
 2. Written documentation of three (3) recent references of Applicator (involving structures with a surface area of 1,000 square feet or greater) indicating successful application of a polymer based polyurethane or a high-build solvent free epoxy product coating system.
 3. Applicator must provide written documentation of having installed a minimum of 20,000 square feet of a product similar to those required in this specification within the last two (2) years.

1.4 Quality Assurance

- A. Applicator shall initiate and enforce quality control procedures consistent with applicable NACE, SSPC, and ASTM standards and the protective coating manufacturer.
- B. Coating manufacturer's authorized representative shall be on site prior to the application of the coating system to verify that the substrate has been properly prepared, and during the application of the coating system to certify that the system has been properly applied. The authorized representative will provide the Owner an accurate and objective written report stating observations on the preparation, application and final inspection verifying adherence to coating manufacturer's recommendations, industry standards and this specification.
- C. The Specialty Subcontractor performing the work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner. The Specialty Subcontractor shall be an approved installer as certified and

licensed by the manufacturer. The Contractor must certify that the proposed product/process to be used is the exact system for which any and all submittals and certifications were made. No substitutions will be allowed, and misrepresentations or omissions may be grounds for Contract termination with the Contractor waiving any and all claims against the Owner for work performed or costs incurred.

1.5 Delivery, Storage, And Handling

- A. Care shall be taken in shipping, handling and storage to avoid damaging the lining materials. Any lining product damaged in shipment, showing deterioration, or which has been exposed to any other adverse storage condition that may have caused damage, even though no such damage is evident, shall be marked as rejected and removed at once from the job site. While stored, the lining products shall be adequately packaged, protected and stored in accordance with the manufacturer's recommendations.

1.6 Site Conditions

- A. Applicator shall conform to all local, state and federal regulations including those set forth by OSHA, RCRA and EPA as well as other applicable authorities.
- B. Method statements and procedures are to be provided by the Applicator when confined space entry is required.
- C. Applicator shall provide safe access to the work site for inspection of the Work.

1.7 Warranty

- A. The contractor shall warrant the entire project to include any and all aspects of the surface preparation, base material installation and protective coating applications for a period of two (2) years from the date of acceptance by the Owner. The warranty shall make no distinction between installation practices and material performance and shall not be prorated with respect to elapsed time for the entire warranty period. Contractor shall, within sixty (60) calendar days after receipt of written notice thereof by the Owner, repair defects in materials or workmanship during said two (2) year period, and any damage to other work caused by such defects or repairing of same at his own expense and without cost to the Owner.

Part 2 Products

- 2.1 The Concrete Repair and Protective Coating are intended to work together as a complete system. As such, all products provided and described herein shall be manufactured by or approved for use by the manufacturer of the coating or rehabilitation system specified.

2.2 Cementitious Repair Material

- A. Cementitious patching, repair and structural restoration materials used shall be only

those specified and pre-approved. Project-specific submittals shall be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the protective coating.

- B. Repair materials shall be used to fill voids, structurally reinforce and/or rebuild substrate surfaces and restore the structure to its original dimensions, etc. as deemed necessary by the Engineer/Owner. Quick blending, rapid setting, high early-strength, fiber- reinforced, non-shrink repair mortar that can be troweled or spray applied must be compatible with the specified protective coating, and shall be applied according to the manufacturer's recommendations.
- C. Repair, Patching and Structural Restoration
 - 1. All materials furnished shall be designed to fill voids and to repair or reconstruct where no hydrostatic pressure exists. Materials shall consist of rapid setting agents, and various accelerating agents. Materials shall not contain chlorides, gypsum or metallic particles.
 - 2. All structural restoration materials shall be specifically designed for rehabilitation of water treatment structures and by NSF/ANSI 61 approved for use with potable water. Materials shall contain poly-fiber reinforcement.
- D. The following products are acceptable and approved as "Structural Restoration" materials for use under this specification:
 - 1. Structural restoration $\frac{1}{2}$ " inch and less in depth
 - a. Carbocrete 4010 by Carboline
 - b. SikaRepair-224 by Sika
 - c. Or approved equal
 - 2. Structural restoration greater than $\frac{1}{2}$ " in depth
 - a. Carbocrete 4010 by Carboline
 - b. QM-1s Restore by Quadex
 - c. Or approved equal
 - 3. Coating primer for exposed reinforcing
 - a. Carboguard 635 by Carboline
 - b. Sika Armatec 110
 - c. Or approved equal

2.3 Protective Epoxy Coating

- A. Epoxy resin-based liners shall be 100% solids by volume, volatile organic compound (VOC) free and shall conform to NSF/ANSI 61 for potable water.
- B. The following products are acceptable and approved as "Protective Epoxy Coating" materials for use under this specification:
 - 1. Cementitious Surfaces: 10 mils DFT (minimum)

- a. Carboguard 561/561 LT by Carboline
- b. Macropoxy 646 NSF Epoxy by Sherwin Williams
- c. PE-54 Epoxy by Induron
- d. N140-1255/AA90 Pota-Pox by Tnemec

Part 3 Execution

3.1 Installers

- A. Repair or restoration mortars must be applied by manufacturer trained and approved applicators. The mortars shall be applied according to the manufacturer's recommendations.
- B. The protective coating must be applied by manufacturer certified and trained applicators. The protective coatings shall be applied according to the manufacturer's recommendations.

3.2 Examination

- A. Appropriate actions shall be taken to comply with all applicable local, state and federal regulatory agencies with regard to health, safety and environmental concerns.
- B. All Bidders are required to verify that they have inspected the work site(s) and are familiar with the conditions and the entire scope of work.
- C. Applicator shall provide minimum 24-hour notice to the Owner and/or the Engineer for the following conditions:
 - 1. After final surface preparation is complete but before structural rehabilitation,
 - 2. After patching/restoration/base coat operations have cured, and
 - 3. After each coating is applied.
- D. Protective coating application shall not commence until the concrete substrate has cured in accordance with these specifications.
- E. Temperature of the surface to be coated shall be maintained between 60° F and 100° F during application. Prior to and during application, care shall be taken to avoid exposure to direct sunlight or other intense heat source to the structure being cured. Where varying surface temperatures do exist, care shall be taken to apply the coating when the temperature is falling versus rising (i.e. late afternoon into evening vs. early morning into afternoon).

3.3 Surface Preparation

- A. Active leakage of all concrete and brick structures shall be stopped by chemical grouting with polyurethane grouts. Grouts shall be installed per manufacturer's

directions.

- B. Applicator shall inspect all surfaces to receive a protective coating prior to surface preparation. Existing piping, valves and appurtenances, if present, shall be protected during structural rehabilitation and protective coating application.
- C. All contaminants including oils, grease, incompatible coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.
- D. All concrete that is not sound, or has been damaged by chemical exposure shall be removed to a sound concrete surface or replaced.
- E. Old concrete must be structurally sound to the satisfaction of the Engineer.
- F. Surface preparation method(s) should be used based upon the condition of the substrate, service environment and the requirements of the manufacturers of the protective coating to be applied.
- G. Surfaces to receive a protective coating shall be cleaned and abraded to produce a sound surface with adequate profile and porosity to provide a strong bond between the protective coating and the substrate. At a minimum, this shall be achieved with low-pressure water cleaning having a 0 degree rotating nozzle at a minimum 3,500 psi and 4 gpm. Other methods, such as high pressure water jetting (refer to NACE Standard No. 6/ SSPC-SP 13), abrasive blasting, shot blasting, grinding, scarifying and/or acid etching may be used. In addition, detergent cleaning and hot water blasting may be necessary to remove oils, grease and other hydrocarbon residue from the concrete. The method(s) used shall be performed in a manner that produces a sound, uniform, clean, neutralized surface that is not excessively damaged.
- H. Create a minimum surface profile for the system specified in accordance with the methods described in ICRI No. 0310.2R to achieve profile:
 - 1. For Original Concrete Substrate (Prior to Resurfacing): CSP 5-9
 - 2. For Resurfaced Concrete Substrate (Prior to Coating): CSP 3-5
- I. Exposed reinforcing shall be inspected by the Engineer. Surface preparation shall follow the guidelines established by ICRI 310.1R. The surrounding concrete shall be chipped out around the full circumference of the reinforcing a minimum of $\frac{3}{4}$." Concrete removal shall extend along the reinforcing until sound reinforcing is exposed. Reinforcing shall be cleaned to SSPC SP 6/11 and coated with a primer compatible with the cementitious repair material. The cementitious repair material shall be used to fill the space around the reinforcing and allowed to cure before applying the surface layer of cementitious repair. Primer and cementitious repair material shall be applied per manufacturer's instructions.
- J. If in the opinion of the Engineer that reinforcement has deteriorated beyond an acceptable degree, reinforcing shall be replaced as described in Section 03 30 00. If

reinforcement replacement is authorized, it will be via change order.

- K. Provide a clean, saturated surface dry (SSD) concrete surface with no free standing or moving water, with a minimum surface profile as defined by ICRI in accordance with 0310.2R equal to a CSP 5-9. All substrates are to be vacuumed, swept and blown down with clean, dry air to remove spent abrasive, dust and other foreign material that might interfere with the adhesion of the primer and lining.
- L. Debris resulting from surface preparation and cleaning shall be removed from the structure.
- M. Surface preparation for steel pipes shall be SSPC SP 5 White Metal Blast Cleaning with a 3.0 mil angular profile.

3.4 Application Of Restoration Materials

- A. Materials shall be applied using proper equipment onto specified surfaces. Restoration materials shall match the original undamaged surface profile.
- B. The approved repair materials shall provide a smooth surface with an average profile equivalent to coarse sandpaper to optimally receive the protective coating. No bug holes or honeycomb surfaces should remain after the final trowel procedure associated with the repair material application.
- C. Repair materials shall be permitted to cure according to manufacturer's recommendations. Curing compounds should not be used unless approved for compatibility with the specified protective coating.
- D. After required cleaning and repair is performed, all surfaces shall be inspected for remaining laitance prior to protective coating application. Any evidence of remaining contamination or laitance shall be removed by additional abrasive blast, shot-blast or other methods approved by the Owner and/or the Engineer. If repair materials are used, refer to these specifications for surface preparation. Areas to be coated must also be prepared in accordance with these specifications after receiving repair mortar and prior to protective coating application.

3.5 Application Of Protective Coatings

- A. Application procedures shall conform to the recommendations of the protective coating manufacturer, including handling, mixing, environmental controls during application, safety and spray equipment.
- B. The equipment shall be specifically designed to accurately ratio and apply the protective coating materials and shall be well maintained and in proper working order for the duration of the Work.
- C. The protective coating must be applied by a "Certified Applicator" of the protective coating manufacturer.

- D. Specified surfaces shall be coated with a moisture tolerant, solvent-free, protective coating exhibiting properties described in these specifications.
- E. Equipment approved by the protective coating manufacturer shall be used to apply each coat of the protective coating.
- F. If necessary, subsequent top-coating or additional coats of the protective coating shall occur as soon as the base coat (if applicable) becomes tack-free, ideally within twelve (12) hours but not later than the recoat window for the specified products. Additional surface preparation procedures shall be required if the recoat window is exceeded.

3.6 Expansion Joint Repair

- A. Clean out existing joint materials and prepare joint in accordance with manufacturer's instructions (existing waterstop to remain if present).
- B. Fill joint to ¼ depth of joint with hydrophilic grout.
- C. Wet joint and allow to expand.
- D. Install backer rod, and seal with urethane joint sealant.
 - 1. In potable water structures, urethane joint sealant shall be NSF/ANSI 61 certified (for contact with drinking water).

3.7 Inspection And Testing

- A. During application, a wet-film thickness gauge meeting ASTM D-4414 shall be used to ensure a uniform thickness during application.
- B. For Cementitious High-Strength Mortar Base Coat.
 - 1. Samples shall be taken of the installed liner each day that the lining is installed:
 - a. Ft of Surface Lined in One Day

| Sq. Ft of Surface Lined in One Day | Quantity of Samples Required |
|------------------------------------|------------------------------|
| 5-50 | 1 (6 Cubes) |
| 51-100 | 2 (12 Cubes) |
| Per Batch of Materials Mixed | 1 (6 Cubes) Per Batch |

- 2. Samples shall be taken at equally spaced intervals throughout the workday. The frequency of tests may be increased by the Engineer and performed by the Contractor at no additional cost to the Owner when the required tests indicate that the installed lining does not meet the Specification.
- 3. Strength and Bonding Testing Procedures: Samples shall be cube samples. A minimum of six cubes shall be taken for each sample testing. The samples

shall be tested in accordance with the applicable ASTM standards, including ASTM C109, to verify that the installed liner meets the compressive strength requirements specified herein and the lining manufacturer's published product data. Tests shall include 7-day and 28-day strength tests (3 cubes for each time period per sample). Shrinkage and bond strength tests shall be performed on each batch or lot of material shipped to the Contractor. Testing shall be performed by an independent laboratory with all associated costs paid by the Contractor. The test results shall be submitted to the Owner immediately when available and no later than 30 days after lining installation.

4. The Engineer and/or Owner shall conduct a visual inspection of the rehabilitated structures in addition to the procedures referenced in this Section. The Contractor shall notify the Owner 48 hours prior to inspection.
5. Any surface failing the test or visual inspection shall be repaired and retested/inspected immediately.
6. The Engineer and/or Owner shall have sole discretion as to whether or not a rehabilitated structure is acceptable.

C. Spark Arrestor (Holiday) Testing

1. All epoxy resin-based linings shall be spark tested prior to being placed in service. Spark testing shall be required of the entire surface area and shall be conducted in accordance with the liner system manufacturer's recommendations.
2. Results of the spark tests will be logged in duplicate and a copy of this log submitted to the Engineer.
3. Equipment systems used to perform spark testing shall be compatible with the materials to be tested. Spark testing equipment shall provide a visual as well as audible indicator to identify pinholes or splits in the liner system.

D. Finished Lining Systems

1. There shall be no groundwater infiltration or other leakage (active or previously active) through the walls or pipe connections after the structure has been lined.
2. If leakage is detected, it shall be eliminated with an appropriate, grout or sealant as recommended by the manufacturer, over coated with epoxy and approved by the Engineer at no additional cost to the Owner. Injection grouting may be required to stop leaks around pipe connections.
3. The Engineer's decision regarding acceptable repair methods for defective linings shall be final. If any lining is found to be defective after it has been installed or during the warranty period, it shall be repaired or replaced in a manner satisfactory to the Engineer and at no additional cost to the Owner.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Concrete formwork.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

A. Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:

B. American Concrete Institute (ACI):

1. 117, Standard Specifications for Tolerances for Concrete Construction and Materials.
2. 318/318R, Building Code Requirements for Reinforced Concrete.
3. 347, Formwork for Concrete.

1.3 Design Requirements

- A. Design, erect, shore, brace, and maintain formwork in accordance with ACI 301, ACI 347, and ACI 318 to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads. Provide concrete finishes specified in Section 03 30 00 - Cast-In-Place Concrete.
- B. When high range water reducer (superplasticizer) is used in concrete mix, forms shall be designed for full hydrostatic pressure per ACI 347.
- C. Make joints in forms tight enough to prevent loss of concrete mortar.
- D. Limit panel deflection to 1/360th of each component span to achieve tolerances specified.

Part 2 Products

2.1 Form Materials

- A. Wall Forms and Underside of Slabs:
 - 1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
- B. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints. Furnish on exposed surfaces and interior surfaces.
- C. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.
- D. Form Release Agent:
 - 1. Material: Release agent shall not bond with, stain, or adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces when applied to forms. A “ready to use” water based material formulated to reduce or eliminate surface imperfections, containing no mineral oil or organic solvents. Environmentally safe, meeting local, state, and federal regulations and can be used in potable water facilities.
 - 2. Manufacturers and Products:
 - a. Master Builders, Inc.; Rheofinish 211.
 - b. Cresset Chemical Company; Crete-Lease 20-VOC.
 - c. US Mix Products Company; US SPEC Slickote.
 - d. Or approved equal.
- E. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

Part 3 Execution

3.1 Form Surface Preparation

- A. Thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants prior to coating surface.
- B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by the manufacturer.

- C. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

3.2 Erection

- A. General: Unless specified otherwise, follow applicable recommendations of ACI 347.
- B. Beveled Edges (Chamfer):
 - 1. Form 3/4" bevels (chamfers) at all exposed concrete edges, unless otherwise shown.
- C. Wall Forms
 - 1. Do not reuse forms with damaged surfaces.
 - 2. Locate form ties and joints in an uninterrupted uniform pattern.
 - 3. Inspect form surfaces prior to installation to assure conformance with specified tolerances.
- D. Form Tolerances: Provide forms in accordance with ACI 117, 347 and 318 and the following tolerances for finishes specified:
 - 1. Wall Tolerances:
 - a. Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
 - b. Wall Type W-A:
 - 1) Plumb within 1/4" in 10' or within 1" from top to bottom for walls over 40 feet high.
 - 2) Depressions in Wall Surface: Maximum 5/16" when 10' straightedge is placed on high points in all directions.
 - 2. Thickness: Maximum -1/4" or +1/2" from dimension shown.
 - 3. Form Offset: Between adjacent pieces of form work, facing material shall not exceed 1/8" where exposed to public view and 1/4" maximum for all other conditions.

3.3 Additional Requirements

- A. Construct forms tight enough to prevent loss of concrete mortar.

- B. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - 1. Install keyways, reglets, recesses and the like for easy removal.
 - 2. Do not use rust-stained steel form-facing material.
 - 3. Use only form or form-tying methods which do not cause spalling of the concrete upon form stripping or tie removal.
- C. Set edge forms, bulkheads and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- D. Provide temporary 12 inch wide x 18 inch high openings for cleanouts and inspection ports every 7 feet at the bottom of each lift form and where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations, where possible.
- E. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt and other debris just before placing concrete.
- F. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- G. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions before placing reinforcement.
- H. Embedded Items.
 - 1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
 - a. Install anchor bolts/rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
 - b. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles and other conditions.
 - c. Check special castings, channels or other metal parts that are to be embedded in the concrete prior to and again after placing the concrete.

- d. Check nailing blocks, plugs and strips necessary for the attachment of trim, finish and similar work prior to placing the concrete.
- I. Removing and reusing forms.
1. General: Do not remove forms from concrete which has been placed with outside temperature below 50°F without first determining and verifying with Engineer if the concrete has properly set without regard for time. Do not apply loading on green concrete. Immediately after forms are removed, the surface of the concrete shall be carefully examined and any irregularities in the surface shall be repaired and finished as specified.
 - a. Leave formwork for structural slabs, beams and other structural elements that support weight of concrete in place until concrete has achieved 100% of its design compressive strength and a minimum of 14 days.
 - b. Formwork for sides of beams, walls, columns and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50°F for 48 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
 - c. For structures with a structural roof slab, leave bracing for walls until the roof slab concrete reaches 100% of its design compressive strength and a minimum of 14 days.
 - d. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
 2. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
 3. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved in writing by the Engineer.
- J. Aluminum surfaces in contact with concrete.
1. Aluminum surfaces in contact with concrete or grout or dissimilar metals shall be protected with a Mylar isolator, bituminous paint or other material approved by Engineer.

K. Shores and reshores.

1. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation and removal of shoring and reshoring.
 - a. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
2. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
3. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Reinforcing steel and related items required for cast-in-place concrete.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

A. American Concrete Institute (ACI):

1. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials
2. ACI 318 - Building Code Requirements for Structural Concrete and Commentary
3. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary

B. Concrete Reinforcing Steel Institute (CRSI) - Manual of Concrete Practice

1.3 Supervision

A. Workmanship: Provide qualified supervision at all times reinforcing work is in progress. Workmen shall be experienced iron workers.

B. Codes: Reinforcement placement and detailing shall comply with practice specified in the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" publication ACI 315- latest edition of the American Concrete Institute or its latest revision, unless otherwise specified herein.

1.4 Submittals

A. Shop drawings: Shop drawings shall be prepared for all reinforcement required by the project. Shop drawings shall be logically and legibly prepared to permit reasonable ease of sorting, selecting, placing reinforcement as well as checking drawings. Preparer and fabricator shall be identified on the drawings.

1. Reinforcement shall not be fabricated until the shop drawings have been processed, approved and returned.
 2. Check all shop drawings to verify reinforcement dimensions required by drawings are satisfied.
 3. Provide bar sizes, bar lengths, bar material, bar grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and lap lengths, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
- B. Reinforcement shop drawings:
1. Review of reinforcement shop drawings by the Engineer will be limited to general compliance with the Contract Documents.
 2. Submit reinforcement shop drawings in a complete package for each specific structure. Partial submittals will be rejected.
- C. Changes to reinforcing steel contract drawing requirements:
1. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.
- D. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.

1.5 Product Handling

- A. Protection:
1. Use all means necessary to protect reinforcement from dirt and other foreign substances before and after placing.
 2. Store in a neat manner in logical order, bundled, tagged, off the ground, and in an area adequately isolated.
 3. Re-bundle to maintain identification when placing is interrupted.
- B. Replacement: All damaged or improperly fabricated bars shall be replaced at the Contractor's expense.

Part 2 Products

2.1 Concrete Reinforcement

A. General:

1. All reinforcement bars shall be deformed, carbon steel bars in accordance with ASTM A615 Grade 60.
2. All reinforcement shall be free from rust, loose mill scale, and other contaminants.

B. Wire bar supports located between reinforcing bars and face of concrete:

1. Stainless steel. Type 304 stainless steel bar supports.
2. Support reinforcing for concrete placed on ground using bar support chairs with Type 304 stainless steel plates for resting on ground welded to the chairs.

C. Concrete bar supports located between reinforcing bars and face of concrete:

1. Manufactured expressly for supporting reinforcing bars.
2. Manufactured with two annealed steel wires to securely tie concrete bar support to reinforcing steel.
3. Manufactured with $f'c$ at least 1,000 psi greater than concrete compressive strength.

2.2 Welded Wire Reinforcement (WWR)

A. General:

1. All WWR shall be carbon steel, welded wire in accordance with ASTM A1064.
2. WWR may not be used in place of reinforcing bars unless accepted in writing by the Engineer.
3. Provide WWR in flat sheet form.

2.3 Accessories

A. General: Accessories shall be subject to Engineer's approval.

B. Tie wire - 18 gauge annealed steel wire.

C. Number of chairs shall be adequate to prevent sag during steel and concrete placement.

- D. Wall layer spacers shall be 1/4 inch round "Z" bar.
- E. Horizontal layer spacers shall be wire bar supports or reinforcing bars bent to support top layer.
- F. Dowel bar splicer shall be Richmond or approved equal, manufactured from standard specified rebar material, with NC threads and shop fabricated to specified dowel configurations.
- G. Expansion Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.
 - 1. All dowels shall be placed and securely anchored before placing concrete. All dowels shall be parallel with each other and perpendicular to the joint.
- H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - 1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
 - 2. Secure all reinforcement in place using steel chairs, supports, "A" bars and any other ACI approved product. Supports shall be spaced adequately to support the steel firmly in place.
 - 3. Chairs will not be accepted to hold reinforcing clearance on walls.

Part 3 Execution

3.1 General

- A. Coordinate all work of other trades to avoid conflict with reinforcement.
- B. Contractor is responsible for checking shop drawings to verify compliance with the drawings. Prior to submitting shop drawings to the Engineer, the contractor shall confirm all bar materials, quantities, sizes, and spacings, as well as all bent bar and lap splice lengths.

3.2 Fabricating

- A. General: Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice." Reinforcement shall be shop fabricated except where straight bars No. 5 or smaller are required.

- B. Bending: All bending shall be by using bending jigs and mandrels. All bars shall be bent cold.
- C. Cutting: Bars shall be cut by cold shearing. Torch cutting in the field may be permitted in special situations.

3.3 Preparation

- A. Surface Preparation:
 - 1. Reinforcing bars: Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars having rust scale, loose mill scale, or thick rust coat.
 - 2. Cleaning of reinforcement materials: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placement.

3.4 Placing

- A. General:
 - 1. Accurately place all bars to meet tolerances as outlined in ACI 318 and tie in place before placing concrete, include dowels. Tie with 18 gauge steel wire.
 - 2. Corner bars required for horizontal reinforcing.
 - 3. No field bending of bars will be allowed.
- B. Clearance:
 - 1. Preserve clearance between bars of 1 inch minimum, not less than one bar diameter or 1-1/3 times large aggregate, whichever is larger.
 - 2. Clear cover shall be as shown in the drawings.
 - 3. Lap all reinforcing bars with a Class B Tension lap or as required by ACI 318.
 - 4. Stagger splices except where otherwise shown.
 - 5. Lap welded wire reinforcement a minimum of two spaces.
- C. Supports:
 - 1. Provide a sufficient number to prevent sagging, to prevent shifting, and to support loads during construction; but in no case less than quantities and at locations as indicated in ACI 315.
 - 2. Do not use brick, broken concrete masonry units, spalls, rocks, wood or similar materials for supporting reinforcing steel.

3. Do not use reinforcing bars that have less cover than required by the Contract Documents. Do not adjust location of reinforcement required by the Contract Documents to provide cover to these bars.
4. Wire chairs will not be accepted to hold reinforcing clearance on walls.

D. Tying of bar reinforcement:

1. Fasten bars securely in place with wire ties.
2. Tie bars sufficiently to prevent shifting during construction or concrete placement.
3. Tie slab bars at every intersection around periphery of slab.
4. Tie wall bars at not greater than following maximum spacings:

| Bar Size | Slab Bar Spacing Inches | Wall Bar Spacing Inches |
|--------------------------------|-------------------------|-------------------------|
| Bars Number 5 and Smaller | 60 | 48 |
| Bars Number 6 through Number 9 | 96 | 60 |
| Bars Number 10 and Number 11 | 120 | 96 |

5. After tying wire ties, bend ends of wire ties in towards the center of the concrete section.
 - a. The cover for wire ties shall be the same as the cover requirements for reinforcing bars.

E. Openings and obstructions:

1. Place additional reinforcing around openings as shown on the drawings and standard details.
2. Consult Engineer on special situations.

F. Welded Wire Reinforcement:

1. Install necessary supports to keep WWR in place while concrete is being placed.
2. Straighten fabric to make flat sheet before placing.
3. Splice fabric in accordance with ACI 318.

END OF SECTION

Part 1 General

1.1 Extent Of The Work

- A. The extent of concrete work is shown on the Drawings.

1.2 Quality Assurance

- A. Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - 1. ACI 301, Specifications for Structural Concrete for Buildings.
 - 2. ACI 302, Guide for Concrete Floor and Slab Placement.
 - 3. ACI 304, Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.
 - 4. ACI 305, Hot Weather Concreting.
 - 5. ACI 306, Cold Weather Concreting.
 - 6. ACI 308, Standard Practice for Curing Concrete.
 - 7. ACI 315, Detailing Manual.
 - 8. ACI 318, Building Code Requirements for Reinforced Concrete.
 - 9. ACI 347, Recommended Practice for Concrete Formwork.
 - 10. ACI 350, Code Requirements for Environmental Engineering Concrete Structures and Commentary.
 - 11. CRSI Manual of Standard Practice.
- B. The Contractor is responsible for correcting concrete work that does not conform to the specified requirements, including requirements for strength, tolerances, and finishes. Correct deficient concrete as directed by the Engineer.
- C. Materials and installed work may require testing and retesting, as directed by the Engineer and paid for by the Soils and Concrete Testing Cash Allowance. Allow free access to material stockpiles and facilities at all times. Tests not specifically indicated to be done at the Owner's expense, including the retesting of rejected materials and installed work, shall be done at the Contractor's expense.

1.3 Submittals

- A. Comply with applicable requirements of Section 01 33 00.
- B. Submit manufacturer/supplier certifications for aggregate and cement. Provide the project identification name and number, date of report, name of Contractor, name of concrete testing service, source of concrete aggregates, materials manufacturer and brand name for manufactured materials, values specified in the referenced specification for each material, and test results.
- C. Submit manufacturer's product data with application and installation instructions for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing and sealing compounds, and others requested by the Engineer.
- D. Submit shop drawings for fabrication, bending, and placement of concrete reinforcement. Comply with the ACI 315, Detailing Manual, showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Show on the shop drawings special reinforcement required and openings through concrete structures.
- E. Submit mix design in accordance with ACI requirements. Provide for each mix design, the project name, city, general contractor, concrete strength, and its intended use.
- F. Submit 2 copies of laboratory test reports with standard deviation analysis or trial batch data. All concrete materials shall be listed.
- G. Submittals shall be approved by the Engineer prior to procurement or fabrication of materials.

Part 2 Products

2.1 Form Materials

- A. Forms for Exposed Finish Concrete: Unless otherwise specified or shown on the Drawings, construct formwork for exposed concrete surfaces with plywood, metal, metal framed plywood, or other panel type materials acceptable to the Engineer in order to provide exposed surfaces that are continuous, straight, and smooth. To minimize the number of joints and to conform to the joint system shown on the Drawings, furnish panels in the largest practicable sizes. Provide form material that is thick enough to withstand pressure of newly placed concrete without bowing or deflection.
- B. Forms for Unexposed Finish Concrete: For surfaces that will be unexposed in the finished structure, form concrete with plywood, lumber, metal, or other material acceptable to the Engineer. If lumber is used, it shall be dressed on at least two edges and one side for tight fit.

- C. Form Coatings: Provide commercial formulation form coating compounds that will not bond with, stain, or adversely affect concrete surface and that will not impair subsequent treatments of concrete surfaces to be cured with water or curing compound.

2.2 Reinforcing Materials

- A. Reinforcing Bar: ASTM A615, Grade 60.
- B. Supports for Reinforcement: Provide supports for reinforcement, including bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Unless otherwise indicated on the Drawings, use wire type bar supports complying with CRSI recommendations. Wood, brick, and other devices will not be acceptable. Comply with the following:
 1. For slabs on grade, where wetted base material will not support chair legs, use supports with sand plates or horizontal runners.
 2. For concrete surfaces exposed to view, where leg supports are in contact with forms, provide supports with legs that are hot dip galvanized or protected by either plastic or stainless steel.

2.3 Concrete Materials

- A. Portland Cement: ASTM C150, Type I or I/II. Use only one brand of cement throughout the project, unless otherwise acceptable to the Engineer.
- B. Fine and Coarse Aggregates: ASTM C33.
- C. Water: Clean, fresh, drinkable.
- D. Admixtures
 1. Water Reducing Admixture: Eucon WR 75, WR-91 or MR by the Euclid Chemical Company, Pozzolith 220-N by Master Builders, or WRDA 15 by W.R. Grace. The admixture shall conform to ASTM C494, Type A, and not contain more chloride ions than are present in municipal drinking water.
 2. Water Reducing, Retarding Admixture: Eucon Retarder 75 by the Euclid Chemical Company or Pozzolith 100 XR by Master Builders. The admixture shall conform to ASTM C494, Type D, and not contain more chloride ions than are present in municipal drinking water.
 3. Mid-range Water Reducing Admixture: Eucon MR or Plastol 341 by the Euclid Chemical Company, Polyheed 997 by Master Builders or Daracem SD by W.R. Grace. The admixture shall conform to ASTM C494 Type A.

4. Nonchloride Accelerator: Accelguard 80, Accelguard 90 or NCA by the Euclid Chemical Company or Darex Set Accelerator by W. R. Grace. The admixture shall conform to ASTM C494, Type C or E, and not contain more chloride ions than are present in municipal drinking water.
5. Air Entraining Admixture: AEA-92 by Euclid Chemical Corporation, MB AE-90 by Master Builders, or Darex AEA by W.R. Grace. The admixture shall conform to ASTM C260.
6. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures containing more than 0.05 percent chloride ions are not permitted.
7. Certification: Written conformance to the aforementioned requirements and the chloride ion content will be required from the admixture manufacturer prior to mix design review by the Engineer.

2.4 Related Materials

- A. Contraction/Construction Joint Filler: The joint filler shall be a two (2) component 100% solids compound, with a minimum shore A hardness of 80. Products: Subject to compliance with requirements, provide "Euco 700 or QWIK Joint" by the Euclid Chemical Company, "Sikadur 51 SL" by Sika Chemical Corporation, or MM-80 by Metzger/McGuire.
- B. Moisture Retaining Covering: One of the following, complying with ASTM C171:
 1. Waterproof paper.
 2. Polyethylene film.
 3. Polyethylene coated burlap.
 4. Waterborne, Membrane Forming Compound: ASTM C309, Type 1, Class B.
- C. Curing and Sealing Compound: Kurez DR VOX or Kurez W VOX by the Euclid Chemical Company, Master Kure 200W by Master Builders or Kure-n-Seal by Sonneborn. The compound shall conform to FS TT C 800A, 30 percent solids content minimum, and have test data from an independent laboratory indicating a maximum moisture loss of 0.030 gram per square centimeter when applied at a coverage rate of 300 square feet per gallon. Manufacturer's certification is required.
- D. Bonding Compound: Euco Weld by Euclid Chemical Company or Weldcrete by the Larsen Company. The compound shall be a polyvinyl acetate, rewettable type.
- E. Epoxy Adhesive: Euco Epoxy No. 452 or No. 620 by Euclid Chemical Company, Sikadur Hi Mod by Sika Chemical Corporation, or Epcon Ceramic 6 by ITW Ramset. The compound shall conform to ASTM C881, be a 2 component, 100 percent solids, 100 percent reactive compound suitable for use on dry or damp surfaces.

- F. Nonshrink Grout: Euco NS by the Euclid Chemical Company or Masterflow 713 by Master Builders. The grout shall conform to CRD C 621 80, "Corps of Engineers Specification for Nonshrink Grout."

2.5 Mix Design

A. Preparation

1. Prepare design mixes for each type and strength of concrete in accordance with applicable provisions of ACI-318 and ASTM C94. Use an independent testing facility acceptable to the Engineer for preparing and reporting proposed mix designs. The testing facility shall not be the same one used for field quality control testing unless this is acceptable to the Engineer. Submit to the Engineer written reports of each proposed mix in accordance with Section 01 33 00.
2. The design mix shall provide normal weight concrete with compressive strength as indicated on the Drawings.

B. Water/Cementitious Ratio:

1. All concrete subject to freezing and thawing shall have a maximum water/cement ratio of 0.45 (4000 psi at 28 days or more). All trowel finished interior slabs, subjected to vehicular traffic, shall have a maximum water/cement ratio of 0.45.

C. Admixtures

1. All concrete slabs placed at air temperatures below 50 degrees F shall contain the specified nonchloride accelerator. All concrete required to be air entrained shall contain an approved air entraining admixture. All pumped concrete, fiber concrete, concrete for floor slabs, and concrete with a water/cement ratio below 0.50 shall contain the specified high range water reducing admixture (superplasticizer) or mid-range water reducing admixture.
 - a. Use an air entraining admixture in all concrete structures and slabs exposed to freezing and thawing or subjected to hydraulic pressure:
 - 1) percent to 5.5 percent for maximum 2 inches aggregate.
 - 2) percent to 7.5 percent for maximum 3/4 inch aggregate.
 - 3) percent to 8.5 percent for maximum 1/2 inch aggregate.
2. Use the amounts of admixtures recommended by the manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control.

D. Slump Limits

1. All concrete containing the high range water reducing admixture (superplasticizer) shall have a maximum slump of 8 inches unless otherwise approved by the Engineer. The concrete shall arrive at the job site at a slump of 2 inches to 3 inches and be verified; then the high range water reducing admixture shall be added to increase the slump to the approved level.
2. All other concrete shall have a maximum slump of 3 inches for slabs and 4 inches for other members.

2.6 Proportioning**A. Ready Mix Concrete**

1. Comply with the requirements of ASTM C94 and of these specifications.
2. During hot weather or under conditions that contribute to rapid setting of concrete, a shorter mixing time than that specified in ASTM C94 may be required. When the air temperature is between 85 degrees and 90 degrees F, reduce the mixing and delivery time from 1 1/2 hours to 75 minutes; when the air temperature is above 90 degrees F, reduce the mixing time to 60 minutes.
3. Each load of concrete arriving at the job shall be accompanied by a delivery ticket that shall be collected by the Contractor and submitted to the Owner's representative and shall contain the following information:
 - a. The design mix and strength of mix of concrete being delivered.
 - b. The exact time the cement, aggregate, and water were discharged into the delivery truck.

Part 3 Execution**3.1 Forms**

- A. Design, erect, support, brace, and maintain formwork to support any vertical and lateral loads that may be applied until such loads can be supported by the concrete structure. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation, and position. Design and construction of form work shall be the responsibility of the Contractor.
- B. Design formwork so that it can be readily removed without impact, shock, or damage to cast in place concrete surfaces and adjacent materials.
- C. Construct forms complying with ACI 347 and ACI SP-4 to the sizes, shapes, lines, and dimensions shown on the Drawings so that in the finished structures the work will be level and plumb and have accurate alignment, location, and grade within the tolerance limits of ACI 301. Provide for openings, offsets, linkages, keyways,

recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages, inserts, and other features that the work requires. Use selected materials to obtain the required finishes. Butt joints solidly and provide backup at joints to prevent leakage of cement paste.

- D. Fabricate forms so that they can be easily removed without hammering or prying against the concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep for the concrete to be placed with bottom forms only. To form keyways, reglets, recesses, and the like, kerf wood inserts to prevent swelling and to permit easy removal.
- E. Where the interior area of formwork is not accessible for cleanout, provide temporary openings to permit concrete placement and inspection before the concrete is placed. Brace temporary openings securely and set them tightly to forms to prevent the loss of concrete mortar. Position temporary openings on forms at inconspicuous locations.
- F. Chamfer exposed corners and edges as shown on the Drawings, using wood, metal, PVC, or rubber chamfer strips fabricated to produce smooth, uniform lines and tight edge joints.
- G. Use metal form ties that are factory made, adjustable in length, designed to prevent form deflection, and either removable or snap off and that will prevent the concrete surface's being spalled when the ties are removed. If snap off ties are used, the portion remaining within the concrete after removal must be at least 1 1/2 inches inside the concrete and be provided with a waterproofing washer unless the Drawings indicate otherwise.
- H. Unless the Drawings indicate otherwise, provide form ties that will not leave holes larger than 1 1/2 inches in diameter in the concrete surface.
- I. Provide openings in concrete formwork to accommodate the work of other trades. Determine the size and location of openings, recesses, and chases from the trades providing such work. Accurately place and securely support items built into forms.
- J. Clean thoroughly forms and adjacent surfaces that are to receive concrete. Remove chips, wood, sawdust, dirt, sediment, and any other debris just before the concrete is placed. After concrete placement, retighten forms if necessary to eliminate mortar leaks.

3.2 Placing Reinforcement

- A. For details and methods of placing reinforcement and supports, comply with the specified codes and standards, the recommended practice of the CRSI as outlined in "Placing Reinforcing Bars," and these specifications.
- B. Clean reinforcement to remove loose rust and mill scale, earth, ice, and other materials that reduce or destroy the bond with concrete.

- C. Accurately position, support, and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcement with metal chairs, runners, bolsters, spacers, and hangers as required for security.
- D. Place reinforcement to obtain at least the minimum coverage for concrete protection as required by ACI 318 and ACI 350 as applicable. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so that ends are directed into the concrete, not toward exposed concrete surfaces.
- E. Do not place reinforcing bars more than 2 inches beyond the last leg of continuous bar support. Do not use supports as bases for runways for concrete conveying equipment or similar construction loads.
- F. Install welded wire fabric in lengths that are as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

3.3 Joints

- A. Locate and install construction joints, as shown on the Drawings, or specified herein, so that the strength and appearance of the structure will not be impaired.
- B. Provide keyways at least 1 1/2 inches deep in construction joints that are in walls and slabs or between walls and footings. Bulkheads designed for this purpose may be used if accepted by the Engineer. Omit keyway where steel waterstops are shown between walls and footings.
- C. Construct isolation joints in slabs on the ground wherever there is contact between slabs on the ground and vertical surfaces and wherever else indicated on the Drawings.
- D. Install joint filler and sealant materials as specified by the manufacturer.
- E. Construct contraction (control) joints in slabs on ground to form panels of patterns as shown. The soff-cut saw system shall be used immediately after final finishing and to a depth of 1/3 slab thickness. A conventional saw shall be used as soon as possible without dislodging aggregate and to a depth of 1/3 slab thickness, if the initial soff-cut did not achieve the 1/3 depth.
- F. Install semi-rigid joint filler or joint sealant in accordance with the direction of the manufacturer.
- G. The maximum joint spacing (in feet) of slabs on grade shall be 30 times the slab thickness (in inches) unless otherwise shown on the Drawings.

3.4 Installation Of Embedded Items

- A. Set and build into the work anchoring devices and other embedded items required for other work that are to be attached to or supported by cast in place concrete. Use setting drawings, diagrams, instructions, and directions provided by the suppliers of the items to be attached thereto.
- B. Set edge forms or bulkheads and intermediate screed strips for slabs in order to provide the elevations and contours in the finished slab surface required by the Drawings. Provide units strong enough to support the types of screed strips used, and secure with strike off templates or compacting screeds accepted by the Engineer.

3.5 Preparation Of Form Surfaces

- A. Before placing reinforcement, coat the contact surfaces of forms with a form coating compound.
- B. Thin the form coating compound only with the amount and type of thinning agent and only under the conditions recommended by the compound manufacturer. Do not allow excess form coating material to accumulate in the forms or to come into contact with concrete surfaces against which fresh concrete will be placed. Apply the form coating compound in compliance with the manufacturer's instructions.
- C. Coat steel forms with a nonstaining, rust preventive form oil, or otherwise protect against rusting. Rust stained steel formwork is not acceptable.

3.6 Concrete Placement

- A. Before placing concrete, inspect and complete the formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades that the formwork is complete so that they may then install their work; cooperate with other trades in setting such work. Wherever form coatings are not used, wet wood thoroughly just before placing concrete.
- B. Coordinate the installation of joint materials and moisture barriers with the placement of forms and reinforcing steel.
- C. Deposit concrete either continuously or in layers thick enough to prevent its being placed on concrete that has hardened enough to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as close to its final location as practicable in order to avoid segregation due to rehandling or flowing.
- D. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner that avoids inclined construction joints. Where placement consists of several layers, avoid cold joints by placing each layer while the preceding one is still plastic.

- E. Use mechanical vibrating equipment supplemented by hand spading, rodding, or tamping to consolidate placed concrete. The equipment and procedures used to consolidate the concrete shall comply with the recommended practices of ACI 309 and suit both the type of concrete and project conditions.
- F. Do not use vibrators to transport concrete once it is inside the forms. Insert and withdraw vibrators vertically at uniformly spaced locations no further apart than the visible horizontal effectiveness of the machine. Limit layer heights so that the vibrator is effective into 6 inches of the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of vibration to the time necessary to consolidate the concrete, and complete embedment of reinforcement and other embedded items without causing segregation of the mix. Lower frequency vibrators may be used with "flowing" concrete.
- G. Until the placing of a panel or section is completed, deposit and consolidate concrete slabs in a continuous operation within construction joints.
- H. Consolidate concrete during placing operations so that it is thoroughly worked around reinforcement and other embedded items and into corners.
- I. Bring slab surfaces to the correct level with a straightedge and strike off. Use highway bull floats or darbies to smooth the surface, leaving it free from humps and hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces before starting finishing operations.
- J. Maintain reinforcement in the proper position during placement operations.
- K. Cold Weather Placement
 1. Comply with ACI 306 and the requirements herein specified to protect concrete work from physical damage or reduced strength due to frost, freezing, or low temperatures.
 2. When the air temperature has fallen or is expected to fall below 40 degrees F, heat all water and aggregates uniformly before mixing so that the concrete, at point of placement, will have a temperature of not less than 50 degrees nor more than 80 degrees F.
 3. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 4. Use only the specified nonchloride accelerator. Do not use calcium chloride or admixtures containing more than 0.05 percent chloride ions.
- L. Hot Weather Placement
 1. When the weather is hot enough to impair the concrete's quality and strength, place the concrete as specified herein and in ACI 305.

2. Cool ingredients before mixing so that when the concrete is placed, its temperature is below 90 degrees F. Mixing water may be chilled, or else a portion of the water may be in the form of chopped ice.
3. If reinforcing steel becomes hotter than the ambient air temperature, cool it with water soaked burlap so that its temperature will not exceed the ambient air temperature.
4. When high temperatures and/or placing or humidity conditions dictate, the mix may be initially retarded by use of the water reducing, retarding formulation (Type D) of the specified water reducing admixture (Type A).

3.7 Finish Of Formed Surfaces

- A. Rough Form Finishes: For formed concrete surfaces not exposed to view in the finished work or covered by other construction, use a rough form finish unless otherwise indicated by the Drawings. Repair and patch tie holes and defective areas and rub down or chip off fins and other projections more than 1/4 inch high.
- B. Smooth Form Finish: For formed concrete surfaces that are exposed to view or to be covered with a coating or covering material applied directly to the concrete or a covering material bonded to the concrete (e.g., waterproofing, dampproofing, painting, etc.), use a smooth form finish. This is the as cast finish obtained on the concrete surface when the selected form facing material is regularly and symmetrically arranged with a minimum of seams. Repair and patch defective areas so that all fins and other projections are completely removed and smoothed.
- C. Rubbed Finish: At all formed surfaces exposed inside and outside the structure, apply rubbed finish as follows:
 1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
- D. Related Uniform Finishes:
 1. At the tops of walls, horizontal offsets, and similar unformed surfaces that are next to formed surfaces, strike off smooth and finish with a texture that matches the adjacent formed surfaces. Unless otherwise shown on the Drawings, continue the final surface treatment of formed surfaces uniformly across adjacent unformed finishes.
- E. Float Finish
 1. Apply float finish to monolithic slab surfaces that are to receive a trowel finish or other finishes specified hereinafter; to slab surfaces that are to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand bed terrazzo; and as otherwise indicated by the Drawings or schedules.

2. After screening, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened enough to permit the operation of power driven floats or by hand floating if the area is small or inaccessible to power units. Check and level the surface plane so that the surface conforms to the specified FF/FL17 tolerance.

F. Trowel Finish

1. Apply a trowel finish to monolithic slab surfaces that are to be exposed to view, unless otherwise indicated by the Drawings, and to slab surfaces that are to be covered with resilient flooring, paint, or other thinfilm finish coating.
2. After the slab has received a floated finish, begin first trowel finish operation using a power driven trowel. Begin final troweling when the surface produces a ringing sound as the trowel is moved over it. Surface shall be troweled until it is free of trowel marks, is uniform in texture and has a smooth dense appearance and achieves an FF30/FL25 tolerance. Grind smooth any surface defects that would telegraph through the applied floor covering.

G. Nonslip Broom Finish

1. Apply nonslip broom finish to exterior concrete platforms, steps, and ramps and elsewhere as indicated by the Drawings or schedules.
2. Immediately after float finishing, roughen the concrete surface slightly by brooming perpendicular to the main traffic route with a fiber bristle broom. Texture shall be as approval by the Engineer from sample panels.

- H. Nonslip Finish: Where the contract documents require a nonslip finish, give the surface a "dry shake" application of crushed ceramically bonded aluminum oxide or other specified selected abrasive particles. The rate of application of such material shall be not less the 25 pounds per 100 SF.

3.8 Curing

- A. After placing and finishing the concrete, start initial curing of concrete as soon as free water has disappeared from concrete surface. Keep continuously moist for not less than 7 days.
- B. Begin final curing immediately after final finishing. Continue final curing for at least 7 days in accordance with ACI 301 and ACI 308. Avoid rapid drying at the end of the final curing period.
- C. Cure concrete by moist curing, moisture retaining cover curing, membrane curing, or combinations of these methods, as specified herein and ACI 308.
- D. Provide moisture curing by one of the following methods:
 1. Keep concrete surface continuously wet by covering with water.

2. Spray it continuously with a water fog.
 3. Cover the concrete surface with the specified absorptive cover, thoroughly saturating the cover with water and keeping it wet; position the absorptive cover so that it covers the concrete surface and edges and laps adjacent absorptive covers by 4 inches.
- E. Provide moisture cover curing by covering concrete surfaces with a moisture retaining cover designed for curing concrete. Place the cover in the widest practicable width of material with sides and ends of the material lapped at least 3 inches and sealed by waterproof tape or adhesive. Repair immediately any holes or tears that occur during the curing period with identical cover material and waterproof tape.
- F. Provide membrane curing to slabs as follows: All interior slabs that have resilient tile or carpet or are left exposed and all exterior slabs, sidewalks, curbs, etc., shall be cured with the specified clear curing and sealing compound. The compound shall be applied immediately after final finishing operations are completed. Apply uniformly in a continuous operation by power spray or roller in accordance with the manufacturer's directions. Areas that are subjected to heavy rainfall within 3 hours after initial application shall be recoated. Maintain continuity of coating, and repair damage during the curing period.
- G. Cure formed concrete surfaces (including undersides of beams, supported slabs, and other similar surfaces) by moist curing with forms in place for the full curing period or until the forms are removed. If forms are removed, continue curing by the methods specified above, as applicable.
- H. Cure unformed surfaces such as slabs, floor topping, and other flat surfaces by the application of the specified curing and sealing compound, strippable curing compound or by a moist curing method approved by the Engineer.

3.9 Removal And Reuse Of Forms

- A. Formwork not supporting weight of concrete (e.g., sides of beams, walls, columns, and similar parts of the work) may be removed after curing at a temperature of not less than 50 degrees F 24 hours after the concrete is placed, provided the concrete is hard enough not to be damaged by form removal operations and provided curing and protection operations are maintained.
- B. Formwork supporting weight of concrete (e.g., beam soffits, joints, slabs, and other structural elements) may not be removed for at least 14 days nor until the concrete has attained a design minimum compressive strength of 28 days. Determine the potential compressive strength of in place concrete by testing the field cured specimens representative of the concrete location or members.
- C. Form facing material may be removed 4 days after concrete placement only if shores and other vertical supports have been arranged to permit it to be removed without loosening or disturbing shores and supports.

- D. Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact form surfaces as specified above for new formwork.
- E. When forms are extended for successive concrete placement, clean surfaces thoroughly, remove fins and laitance, and tighten forms to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces.

3.10 Miscellaneous Concrete Items

- A. Filling In: Unless the Drawings show otherwise or the Engineer directs, fill in holes and openings left in concrete structures for the work of other trades once that work is in place. Mix, place, and cure concrete as specified herein to blend with in place construction. Provide other miscellaneous concrete filling shown on the Drawings or necessary to complete the work.
- B. Nonshrink Grout: All column base plates, equipment bases, and other locations noted on the structural drawings shall be grouted with the specified nonshrink grout. All exposed grout shall be of the specified nonmetallic type.
- C. Reinforced Masonry: Provide concrete grout for reinforced masonry lintels and bond beams where indicated on the Drawings and as scheduled. Maintain accurate location of reinforcing steel during concrete placement.

3.11 Concrete Surface Repairs

- A. Repair and patch defective areas with cement mortar immediately after removing forms.
- B. Cut out honeycomb, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts down to solid concrete, but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Before placing cement mortar, thoroughly clean, dampen with water, and apply the specified bonding compound. The cement mortar shall be placed after the bonding compound has dried.
- C. Remove and replace concrete with defective surfaces if these effects cannot be repaired to the satisfaction of the Owner and Engineer. Such surface defects include irregularities of color and texture, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry pack mortar or with precast cement cone plugs secured in place with bonding agent.
- D. Where possible, repair concealed formed surfaces that contain defects which adversely affect the durability of the concrete. If such defects cannot be repaired, remove and replace the concrete.

- E. Test unformed surfaces such as monolithic slabs for smoothness and to verify that the surface plane meets the tolerances specified for each surface and finish. Correct low and high areas as specified herein. Test unformed surfaces sloped to provide drainage for both trueness of slope and smoothness with a template of the slope specified on the Drawings.
- F. Repair finished unformed surfaces that contain defects which adversely affect durability of the concrete. Such surface defects include crazing, spalling, pop outs, honeycomb, rock pockets, cracks that are more than 0.01 inch wide or that, regardless of width, penetrate either to reinforcement or completely through unreinforced sections, and other objectionable conditions.
- G. After the concrete has cured at least 14 days, correct high areas in unformed surfaces by grinding.
- H. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting them out and refilling with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to the Engineer.
- I. Repair defective areas (except for random cracks and single holes not more than 1 inch in diameter) by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts, and expose reinforcing steel with at least 3/4 inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply the specified bonding compound. Place patching concrete after the bonding compound has dried. Mix patching concrete of the same materials to provide concrete of the same type or class as the original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.
- J. Repair isolated random cracks and single holes not over 1 inch in diameter by the dry pack method. Groove top of cracks, cut out holes until sound concrete is reached, and clean to remove dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply the specified bonding compound. Place dry pack after the bonding compound has dried. Dry pack shall consist of one part portland cement to 2 1/2 parts fine aggregate passing a No. 16 mesh sieve. Mix with no more water than is necessary for handling and placing. Compact dry pack mixture in place, and finish to match adjacent concrete. Keep patched area continuously moist for no less than 72 hours.
- K. All structural repairs shall be made, with prior approval of the Engineer as to the method and procedure, using the specified epoxy adhesive and/or epoxy mortar.
- L. Repair methods not specified above may be used, subject to acceptance by the Engineer.

3.12 Quality Control Testing During Construction

- A. The Contractor will employ a testing laboratory to perform any or all of the tests specified below and to submit reports on these tests. The testing laboratory shall be approved by the Owner and shall be paid for by the Soils and Concrete Testing Cash Allowance. Sampling and testing for quality control during the placement of concrete may include the following, as directed by the Engineer:
1. Sampling Fresh Concrete: ASTM C172 but modified for slump to comply with ASTM C94.
 2. Slump: ASTM C143; one test for each concrete load at point of discharge and one test of each set of compressive strength test specimens.
 3. Air Content: ASTM C173 volumetric method for lightweight concrete; ASTM C231 pressure method for normal weight concrete; one test for each set of compressive strength test specimens.
 4. Water Content: The water content of freshly mixed concrete will be tested each time cylinders are made and as directed by the Engineer in accordance with AASHTO TP 23, Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying.
 5. Concrete Temperature: Test hourly when air temperature is 40 degrees F and below or when 80 degrees F and above and each time a set of compression test specimens is made.
 6. Compression Test Specimen: ASTM C31; one set of 6 standard cylinders for each compressive strength test, unless otherwise directed by the Engineer. Mold and store cylinders of laboratory cured test specimens except when the Engineer requires field cured test specimens.
 7. Compressive Strength Tests: ASTM C39; one set for each 100 cubic yards or fraction thereof of each concrete class placed in any one day or one set for each 5,000 square feet of surface area placed; 2 specimens tested at 7 days, 2 specimens tested at 28 days, and 1 specimen retained in reserve for later testing, if needed.
- B. When the frequency of testing provides less than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or, if fewer than 5 are used, from each batch.
- C. The strength level shall be considered satisfactory as long as the averages of all sets of 3 consecutive strength test results equal or exceed the specified strength f'_c , and no individual test result falls below the specified strength f'_c by more than 500 psi.
- D. When the strength of field cured cylinders is less than 85 percent of companion laboratory cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in place concrete.

- E. Test results will be reported to the Engineer and Contractor in writing on the same day that the test is made. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in the structure, design compressive strength at 28 days, concrete mix proportions and materials, and compressive breaking strength and type of break for both 7 day tests and 28 day tests.

- F. Non-Compliant Test Reports: All test reports indicating non-compliance should be provided immediately to all parties on the test report distribution list. The testing service will make additional tests of in place concrete when the test results indicate that the required strength level has not been achieved and other characteristics have not been attained in the structure, as directed by the Engineer. The testing service may conduct tests to determine the adequacy of concrete by cored cylinders that comply with ASTM C42 or by such other methods as are directed by the Engineer. The Contractor shall pay for such tests and any additional testing that may be required when concrete is verified to be unacceptable.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Epoxy/polyurethane injection system.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 Unit Price

A. Work of this Section is affected by unit prices specified in Item 3 of the Bid Form 00 41 00.

1. Unit prices apply to authorized work covered by estimated quantities.
2. Unit prices apply to authorized additions to and deletions from the Work as authorized by Change Orders.

B. General: Unit prices include the cost of preparing existing construction to receive the work indicated and costs of field quality control required for units of work completed.

1.3 References

A. ASTM International (ASTM):

1. D 638, Standard Test Method for Tensile Properties of Plastics.
2. D 648, Standard Test Method for Deflection of Plastics under Flexural Load.
3. D 695, Standard Test Method for Compressive Properties of Rigid Plastics.
4. D 790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.4 Definitions

A. Epoxy/polyurethane Injection Repair Areas: Areas deemed to be defective and requiring large crack repair.

- B. Defective Areas: Surface defects that include honeycomb, rock pockets, and indentations greater than 3/16"; cracks 0.010" wide and larger, as well as any crack that leaks, for hydraulic structures and below grade habitable spaces; cracks 0.015" wide and larger in non-hydraulic structures; spalls; chips; air bubbles greater than 3/4" in diameter; pinholes; bug holes; embedded debris; fins and other projections; form pop-outs; texture irregularities; and stains that cannot be removed by cleaning.
- C. Large Cracks: Wider than 0.015".
- D. Small Cracks: Width greater than or equal to 0.010" and less than or equal to 0.015", as well as any smaller cracks that leak.

1.5 Submittals

- A. Information Submittals:
 - 1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy or polyurethane injection system.
 - 2. Manufacturer's product data for epoxy/polyurethane injection system.
 - 3. Statements of Qualification for Epoxy/Polyurethane Injection Material:
 - a. Manufacturer's site representative.
 - b. Injection applicator.
 - c. Injection pump operating technician.

1.6 Quality Assurance

- A. Qualifications for Epoxy/Polyurethane Injection Staff:
 - 1. Manufacturer's Site Representative:
 - a. Capable of instructing successful methods for restoring concrete structures utilizing injection process.
 - b. Understands and is capable of explaining technical aspects of correct material selection and use.
 - c. Experienced in the operation, maintenance, and troubleshooting of application equipment.
 - 2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
 - a. Licensed and certified by epoxy/polyurethane Manufacturer.

- b. Minimum 3 years' experience in successful epoxy/polyurethane injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.7 Delivery, Storage, And Handling

- A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:
 - 1. Manufacturer's name.
 - 2. Product name and lot number.
 - 3. ANSI Hazard Classification (formerly SPI Classification).
 - 4. ANSI recommended precautions for handling.
 - 5. Mix ratio by volume.
- B. Storage and Protection: Store adhesive containers at ambient temperatures below 120 °F and above 32 °F.

Part 2 Products

2.1 Manufacturers

- A. Epoxy Injection Material equal to:
 - 1. Sika Corp., Lyndhurst, NJ; Sikadur-52 N/LP (or approved equal).
- B. Polyurethane Injection Material equal to:
 - 1. Sika Corp., Lyndhurst, NJ; Sika Injection-215 (or approved equal).
 - 2. Sika Corp., Lyndhurst, NJ; Sika Injection-304 (or approved equal).
 - 3. Sika Corp., Lyndhurst, NJ; Sika Injection-307 (or approved equal).

2.2 Surface Seal

- A. Sufficient strength and adhesion for holding injection fittings firmly in-place, and to resist pressures preventing leakage during injection.
- B. Capable of removal after injection adhesive has cured.

Part 3 Execution

3.1 General

- A. Large Cracks: Repair by injection of epoxy or polyurethane as noted on drawings.
- B. Small Cracks: Repair according to 03 01 00 - Concrete Surface Repair Systems.

3.2 Preparation

- A. Clean cracks in accordance with epoxy/polyurethane manufacturer's instructions.
- B. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.
- C. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy/polyurethane.

3.3 Application

- A. Sealing: Apply surface seal in accordance with Manufacturer's instructions to designated crack face prior to injection. Seal surface of crack to prevent escape of injection epoxy/polyurethane.
- B. Entry Ports:
 - 1. Determine space between entry ports equal to thickness of concrete member to allow epoxy/polyurethane to penetrate to the full thickness of the wall.
 - 2. Clean entry ports after drilling.
 - 3. Space entry ports close together to allow adjustment of injection pressure to obtain minimum loss of epoxy/polyurethane to soil at locations where:
 - a. Cracks extend entirely through wall.
 - b. Backfill of walls on one side.
 - c. Difficult to excavate behind wall to seal both crack surfaces.
- C. Epoxy/polyurethane Injection:
 - 1. Store epoxy/polyurethane at minimum of 70 °F.
 - 2. Start injection into each crack at lowest elevation entry port.
 - 3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.

4. Plug first port and start injection at second port until adhesive flows from next port.
5. Inject entire crack with same sequence.

D. Finishing:

1. Cure epoxy/polyurethane adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy/polyurethane material from cracks.
2. Remove surface seal from cured injection adhesive.
3. Finish crack face flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports are not acceptable.
5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

3.4 Equipment

- A. Portable, positive displacement type pumps with in-line metering to mix two adhesive components, and inject mixture into crack, and as required by injection system manufacturer.

3.5 Field Quality Control

A. Epoxy/Polyurethane Adhesive Two Component Ratio Tests:

1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both adhesive components.
3. Simultaneously discharge both adhesive components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1-hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
2. Pressure Check Device:
 - a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
 - b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
 - a. Beginning and end of each injection work day.
 - b. When injection work has stopped for more than 1-hour.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Miscellaneous steel framing and supports.
 - 2. Metal floor plate.

1.2 Action Submittals

- A. Shop Drawings: Show fabrication and installation details.

Part 2 Products

2.1 Metals

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Rolled-Steel Floor Plate: ASTM A786/A786M, rolled from plate complying with ASTM A36/A36M or ASTM A283/A283M, Grade C or D.

2.2 Fasteners

- A. General: Unless otherwise indicated, provide Type 316 stainless steel fasteners for interior and exterior use.
- B. Post-Installed Anchors: chemical anchors.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.

2.3 Miscellaneous Materials

- A. Water-Based Primer: Emulsion type, anticorrosive primer for mildly corrosive environments that is resistant to flash rusting when applied to cleaned steel, complying with MPI#107 and compatible with topcoat.
- B. Concrete: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained concrete with a minimum 28-day compressive strength as specified in the design drawings.

2.4 Fabrication, General

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.5 Miscellaneous Framing and Supports

- A. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

2.6 Metal Floor Plate

- A. Fabricate from rolled-steel floor plate of thickness indicated below:
 - 1. Thickness: As indicated.

2.7 General Finish Requirements

- A. Finish metal fabrications after assembly.

2.8 Steel and Iron Finishes

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
- B. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."
- C. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

Part 3 Execution

3.1 Installation, General

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 Installation of Miscellaneous Framing and Supports

- A. Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

3.3 Repairs

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Aluminum pipe and tube railings.

1.2 Coordination

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.3 Action Submittals

- A. Product Data: For the following:
 - 1. Manufacturer's product lines of mechanically connected railings.
 - 2. Railing brackets.
 - 3. Grout, anchoring cement, and paint products.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- C. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 Informational Submittals

- A. Qualification Data: For testing agency.
- B. Welding certificates.
- C. Mill Certificates: Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.

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- D. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
- E. Product Test Reports: For pipe and tube railings, for tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.
- F. Evaluation Reports: For post-installed anchors, from ICC-ES.

1.5 Quality Assurance

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.6 Delivery, Storage, and Handling

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1.7 Field Conditions

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

Part 2 Products

2.1 Manufacturers

- A. Aluminum Pipe and Tube Railings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ATR Technologies, Inc.
 - b. Blum, Julius & Co., Inc.
 - c. Braun, J. G., Company.
 - d. CraneVeyor Corp.
 - e. Hollaender Manufacturing Company.
 - f. Kee Industrial Products, Inc.
 - g. Moultrie Manufacturing Company.
 - h. Sterling Dula Architectural Products, Inc; Div. of Kane Manufacturing.

- i. Superior Aluminum Products, Inc.
 - j. Thompson Fabricating, LLC.
 - k. Tri Tech, Inc.
 - l. Tubular Specialties Manufacturing, Inc.
 - m. Tuttle Railing Systems.
 - n. Wagner, R & B, Inc.
- B. Source Limitations: Obtain each type of railing from single source from single manufacturer.

2.2 Performance Requirements

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design railings, including attachment to building construction.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
- 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft.
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
- 1. Temperature Change: 120 deg F, ambient; 180 deg F.

2.3 Aluminum

- A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.

- B. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
 - 1. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.

2.4 Fasteners

- A. General: Provide the following:
 - 1. Aluminum Railings: Type 304 stainless-steel fasteners.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
 - 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.

2.5 Miscellaneous Materials

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - 1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- B. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.6 Fabrication

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.

- E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with either welded or nonwelded connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove flux immediately.
 - 4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.
- I. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
- J. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - 1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.
- K. Form Changes in Direction as Follows:
 - 1. By bending or by inserting prefabricated elbow fittings.
 - 2. By flush bends or by inserting prefabricated flush-elbow fittings.
- L. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- M. Close exposed ends of railing members with prefabricated end fittings.
- N. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.

- O. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
 - 1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
- P. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
- Q. For railing posts set in concrete, provide steel sleeves not less than 6 inches long with inside dimensions not less than 1/2 inch greater than outside dimensions of post, with metal plate forming bottom closure.
- R. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.7 Aluminum Finishes

- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Mill Finish: AA-M12, nonspecular as fabricated.
- C. Clear Anodic Finish: AAMA 611.

Part 3 Execution

3.1 Examination

- A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.2 Installation, General

- A. Fit exposed connections together to form tight, hairline joints.
- B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
 3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.
- C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
1. Coat, with a heavy coat of bituminous paint, concealed surfaces of aluminum that are in contact with grout, concrete, masonry, wood, or dissimilar metals.
- D. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.3 Railing Connections

- A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.
- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.4 Anchoring Posts

- A. Use metal sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Form or core-drill holes not less than 5 inches deep and 3/4 inch larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.

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- C. Cover anchorage joint with flange of same metal as post, attached to post with set screws.
- D. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For aluminum pipe railings, attach posts using fittings designed and engineered for this purpose.
- E. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

3.5 Attaching Railings

- A. Anchor railing ends at walls with round flanges anchored to wall construction and welded to railing ends or connected to railing ends using nonwelded connections.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends or connected to railing ends using nonwelded connections.
- C. Attach railings to wall with wall brackets, except where end flanges are used. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- D. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete anchorage, use drilled-in expansion shields and hanger or lag bolts.

3.6 Adjusting and Cleaning

- A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.7 Protection

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION

Part 1 General

1.1 Work Included

- A. Surface preparation.
- B. Field application of paints and other coatings.
- C. Materials for back-priming woodwork.
- D. Scope:
 - 1. All interior surfaces in the existing Pipe Gallery in the 1969 Building that are currently coated and exposed to view are to be recoated, including, but not limited to: structural steel catwalks, handrails, platforms, concrete walls and ceilings, CMU walls, piping and piping accessories, and electrical conduit.
 - 2. All coated surface areas in the existing Pipe Galley in the 1949 Building that are exhibiting deteriorated and failing coatings shall be recoated.
 - 3. All new components exposed to view are to be painted, unless fully factory-finished or unless otherwise indicated, including the following:
 - a. Paint all exposed pipes, pipe couplings, valves, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports, mechanical equipment, and electrical equipment, unless otherwise indicated.
 - b. Paint shop-primed items.
 - 4. All existing surfaces that are damaged or marred during construction shall be recoated as directed by Engineer.
 - 5. Sedimentation Basin Repair: See Section 03 01 30.71 – Rehab of Concrete.
- E. Do Not Paint or Finish the Following Items:
 - 1. Items fully factory-finished unless specifically so indicated; materials and products having factory-applied primers are not considered factory finished.
 - 2. Items indicated to receive other finishes.
 - 3. Items indicated to remain unfinished.
 - 4. Fire rating labels, equipment serial number and capacity labels, and operating parts of equipment.
 - 5. Stainless steel, anodized aluminum, bronze, terne, and lead items.

6. Floors, unless specifically so indicated.
7. Concealed pipes, ducts, and conduits.
8. Operating parts or machined surfaces.

1.2 Definitions

- A. Conform to ASTM D16 for interpretation of terms used in this section.

1.3 Submittals

- A. See Section 01 33 00 – Submittal Procedures for submittal procedures.
- B. Product Data: Provide data on all finishing products, including VOC content.
- C. Samples: Submit two paper chip samples, 3" x 5" inch (76.2 x 127 mm) in size illustrating range of colors and textures available for each surface finishing product scheduled.
- D. Paint Schedule: Provide list, by process area or building, of all surfaces to be coated, with selected coating system identified. Where required colors are identified in other Sections, provide color chart and identify required colors on paint schedule. Where required colors are not identified, leave space for Owner to provide selected color.
- E. Piping Identification layout and colors.
- F. Certificates
 1. Applicator's Qualifications.
 2. Qualification Testing laboratory for coatings.
 3. Indoor Air Quality data for Paints and Primers.
 - a. For occupied indoor spaces, provide paint and coating products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification by other third-party programs. Provide current product certification documentation from certification body.
- G. Manufacturer's Instructions
 1. Application Instructions: Indicate special surface preparation procedures.
 2. Mixing: Detailed mixing instructions, minimum and maximum application temperature and humidity, potlife, and curing and drying times between coats.
 3. Manufacturer's Safety Data Sheets.

- H. Maintenance Data: Submit data on cleaning, touch-up, and repair of painted and coated surfaces.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 78 43 - Spare Parts and Special Tools, for additional provisions.
 - 2. Extra Paint and Coatings: 1 gallon (4 L) of each color; store where directed.
 - 3. Label each container with color in addition to the manufacturer's label.

1.4 Quality Assurance

- A. Required Standards: Coatings subcontractor shall have and maintain on-site during all coating operations the proper industrial standards for use by the Owner or Owner's representative. Industrial standards to be maintained on-site include:
 - 1. SSPC (Structural Steel Painting Council) Steel Structures Painting Manual, Volume 1.
 - 2. SSPC-VIS-1 - Pictorial Surface Preparation Standards for Painting Steel Surfaces.
- B. Required Inspection Tools: Coatings subcontractor shall have and maintain on-site during all coating operations the proper industrial paint inspection tools for use by the Owner or Owner's representative. Inspection tools to be maintained on-site shall include, as appropriate:
 - 1. Sling psychrometer kit
 - 2. Testex tape kit
 - 3. Zahn Cups Nos. 2, 3, 4 and 5 with a thermometer for air spray paint
 - 4. Nordsen Mikrotest or equal wet mil gauge
 - 5. National Bureau of Standard Calibration Chips
 - 6. Took Gauge
 - 7. Elcometer 10612 Pull Off Adhesion gauge with aluminum dollies and epoxy glue
- C. Contractor shall obtain, from the supplier/manufacturer, material safety data sheets (MSDS) for all products, as well as any other special handling, application and cleanup precautions or recommendations. Contractor shall be responsible to follow these safety recommendations and precautions.

- D. Single Source Responsibility: Provide primers and other undercoat paint produced by the same manufacturer as finish coats. Use only thinner approved by paint manufacturer, and use only within recommended limits.
- E. NSF Approval: All coating materials in contact with potable water shall comply with ANSI/NSF Standards 61, latest revision.

1.5 Qualifications

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years' experience in utility applications. The paints and paint products mentioned in the following specifications are set up as standards of quality. No request for substitution will be considered which decreases the film thickness and/or the number of coats to be applied, or which offers a change from the generic type of coating specified.
- B. Applicator's Qualifications:
 - 1. Submit the name, address, telephone number, fax number, and e-mail address of the contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on potable water piping systems on a minimum of five similar projects within the past five years. List information by individual and include the following:
 - a. Name of individual and proposed position for this work.
 - b. Information about each previous assignment including:
 - 1) Position or responsibility.
 - 2) Employer (if other than the Contractor).
 - 3) Name of facility owner.
 - 4) Mailing address, telephone number, and telex number (if non-US) of facility owner.
 - 5) Name of individual in facility owner's organization who can be contacted as a reference.
 - 6) Location, size and description of structure.
 - 7) Dates work was carried out.
 - 8) Description of work carried out on structure.

1.6 Regulatory Requirements

- A. Environmental Protection
 - 1. In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local or regional jurisdiction. Notify Engineer of any paint specified herein which fails to conform.
- B. Lead Content: Do not use coatings having a lead content over 0.06 percent by weight of non-volatile content.
- C. Chromate Content: Do not use coatings containing zinc-chromate or strontium-chromate.
- D. Asbestos Content: Provide asbestos-free materials.
- E. Mercury Content: Provide materials free of mercury or mercury compounds.
- F. Silica: Provide abrasive blast media containing no free crystalline silica.
- G. Human Carcinogens: Provide materials that do not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.7 Delivery, Storage, and Handling

- A. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
- B. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Paint Materials: Store at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.
- D. Furnish pigmented paints in containers not larger than five gallons.
- E. Do not store paint, polyurethane, varnish, or wood stain products with materials that have a high capacity to adsorb VOC emissions. Do not store paint, polyurethane, varnish, or wood stain products in occupied spaces.

1.8 Field Conditions

- A. Coatings shall be applied during good painting weather. Air and surface temperatures shall be within limits prescribed by the manufacturer for the coating being applied and work areas shall be reasonably free of airborne dust at the time of application and while coating is drying.

- B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates, and humidity and temperature limitations.
- C. Provide lighting level of 80 ft candles (860 lx) measured mid-height at substrate surface.

1.9 Coordination

- A. Coordinate work under provisions of Division 1.
- B. Coordination of Work: review other sections of these specifications in which prime paints are to be provided to ensure compatibility of total coatings system for various substrates. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.

Part 2 Products

2.1 Materials

- A. All materials specified herein shall be as manufactured by:
 - 1. TNEMEC Co., Inc., North Kansas City, Missouri.
 - 2. Carboline, St. Louis, Missouri.
 - 3. Induron, Birmingham, Alabama.
 - 4. The Sherwin-Williams Company, Cleveland, Ohio.
 - 5. These products are specified to establish standards of quality and are approved for use on this project.
- B. Colors, where not specified, shall be as selected by the A/E from the paint manufacturer's color chart. All colors shall be certified lead free.
 - 1. In utility areas, finish equipment, piping, conduit, and exposed duct work in colors according to the color coding scheme indicated.

2.2 Paints and Coatings - General

- A. Paints and Coatings: Ready mixed, unless intended to be a field-catalyzed coating.
 - 1. Provide paints and coatings of a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating, with good flow and brushing properties, and capable of drying or curing free of streaks or sags.

2. Provide materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
 3. For opaque finishes, tint each coat including primer coat and intermediate coats, one-half shade lighter than succeeding coat, with final finish coat as base color.
 4. Supply each coating material in quantity required to complete entire project's work from a single production run.
 5. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.
- B. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.
- C. Volatile Organic Compound (VOC) Content: Provide coatings that comply with the most stringent requirements specified in the following:
1. Local or state regulations
 2. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings.
 3. Determination of VOC Content: Testing and calculation in accordance with 40 CFR 59, Subpart D (EPA Method 24), exclusive of colorants added to a tint base and water added at project site; or other method acceptable to authorities having jurisdiction.

Part 3 Execution

3.1 Examination

- A. Verify that surfaces are ready to receive work as instructed by the product manufacturer.
- B. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application.
- C. Test shop-applied primer for compatibility with subsequent cover materials.
- D. Measure moisture content of surfaces using an electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums:
 1. Masonry, Concrete, and Concrete Unit Masonry: 12 percent.
 2. Concrete Floors and Traffic Surfaces: 8 percent.

3.2 Protection of Areas and Spaces Not to be Painted

- A. Prior to surface preparation and coating applications, remove, mask, or otherwise protect hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated.
- B. Following completion of painting, reinstall removed items by workmen skilled in the trades.
- C. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.3 Surface Preparation

- A. Clean surfaces thoroughly and correct defects prior to coating application.
 - 1. Remove dirt, splinters, loose particles, grease, oil, [disintegrated coatings,] and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments.
 - 2. Remove oil and grease prior to mechanical cleaning.
- B. Schedule cleaning so that dust and other contaminants will not fall on wet, newly painted surfaces. Spot-prime exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.
- C. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- D. Additional Requirements for Preparation of Surfaces With Existing Coatings
 - 1. Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:
 - a. Test existing finishes for lead before sanding, scraping, or removing. If lead is present, refer to paragraph Toxic Materials.
 - b. Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D235. Allow surface to dry.
 - 1) Wipe immediately preceding the application of the first coat of any coating, unless specified otherwise.
 - c. Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.

-
- d. Comply also with the application instructions of the paint manufacturer.
 - e. Thoroughly clean previously painted surfaces [specified to be repainted] [damaged during construction] of all grease, dirt, dust or other foreign matter.
 - f. Remove blistering, cracking, flaking and peeling or otherwise deteriorated coatings.
 - g. Remove chalk so that when tested in accordance with ASTM D4214, the chalk resistance rating is no less than 8.
 - h. Roughen slick surfaces. Repair damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls with suitable material to match adjacent undamaged areas.
 - i. Feather and sand smooth edges of chipped paint.
 - j. Clean rusty metal surfaces as per SSPC requirements. Use solvent, mechanical, or chemical cleaning methods to provide surfaces suitable for painting.
 - k. Provide new, proposed coatings that are compatible with existing coatings.
- E. Existing Coated Surfaces with Minor Defects
- 1. Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings.
- F. Removal of Existing Coatings
- 1. Remove existing coatings from the following surfaces:
 - a. Surfaces containing large areas of minor defects;
 - b. Surfaces containing more than 20 percent peeling area; and
 - c. Surfaces designated by the Engineer, such as surfaces where rust shows through existing coatings.
- G. Substrate Repair
- 1. Repair substrate surface damaged during coating removal;
 - 2. Sand edges of adjacent soundly-adhered existing coatings so they are tapered as smooth as practical to areas involved with coating removal; and
 - 3. Clean and prime the substrate as specified.

3.4 Preparation Of Metal Surfaces

- A. Existing and New Ferrous Surfaces

- B. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to requirements of painting schedule. Protect shop-coated ferrous surfaces from corrosion by treating and touching up corroded areas immediately upon detection.

- C. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with painting schedule.

- D. Ductile Iron Pipe with Existing Coatings: Existing ductile iron pipes to be recoated shall have existing coating removed by abrasive blast cleaning in accordance with NAPF 500-03-04 for pipe and NAPF 500-03-05 for fittings.

- E. Final Ferrous Surface Condition:
 - 1. For tool cleaned surfaces, the requirements are stated in SSPC SP 2 and SSPC SP 3. Use as a visual reference, photographs in SSPC VIS 3 for the appearance of cleaned surfaces.
 - 2. For abrasive blast cleaned surfaces, the requirements are stated in SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and SSPC SP 10/NACE No. 2. Use as a visual reference, photographs in SSPC VIS 1 for the appearance of cleaned surfaces.
 - 3. For waterjet cleaned surfaces, the requirements are stated in SSPC SP 12/NACE No.5. Use as a visual reference, photographs in SSPC VIS 4/NACE VIS 7 for the appearance of cleaned surfaces.

- F. Non-Ferrous Metallic Surfaces
 - 1. Aluminum and aluminum-alloy, lead, copper, and other non-ferrous metal surfaces.
 - a. Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.
 - 2. Terne-Coated Metal Surfaces
 - a. Solvent clean surfaces with mineral spirits, ASTM D235. Wipe dry with clean, dry cloths.

G. Existing Surfaces with a Bituminous or Mastic-Type Coating

1. Remove chalk, mildew, and other loose material by washing with a solution of 1/2 cup trisodium phosphate, 1/4 cup household detergent, one quart 5 percent sodium hypochlorite solution and 3 quarts of warm water.

3.5 Preparation of Concrete and Cementitious Surface

A. Concrete and Masonry

1. Curing: Allow concrete, stucco and masonry surfaces to cure at least 30 days before painting, and concrete slab on grade to cure at least 90 days before painting.
2. Surface Cleaning: Remove the following deleterious substances.
 - a. Dirt,[Chalking,] Grease, and Oil: Wash new[and existing uncoated] surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, and 4 quarts of warm water. Then rinse thoroughly with fresh water.[Wash existing coated surfaces with a suitable detergent and rinse thoroughly.] For large areas, water blasting may be used.
 - b. Fungus and Mold: Wash [new][, existing coated,] [and existing uncoated] surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, 1 quart 5 percent sodium hypochlorite solution and 3 quarts of warm water. Rinse thoroughly with fresh water.
 - c. Paint and Loose Particles: Remove by wire brushing.
 - d. Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 4 square feet of surface, per workman, at one time.
3. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

3.6 Materials Preparation

- A. Mix and prepare painting materials in accordance with manufacturer's directions.
- B. Maintain containers used in mixing and application of paint in a clean condition free of foreign materials and residue.
- C. Stir materials before application to produce a mixture of uniform density, and stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

- D. Two-Component Systems: Mix two-component systems in accordance with manufacturer's instructions. Follow recommendation by the manufacturer for any thinning of the first coat to ensure proper penetration and sealing for each type of substrate.

3.7 Application

- A. General: Apply paint in accordance with manufacturer's directions and with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein.. Use applicators and techniques best suited for substrate and type of material being applied.
1. Provide finish coats which are compatible with prime paints used.
 2. Apply additional coats when undercoats, stains or other conditions show through final coat of paint, until a paint film is of uniform finish.
 3. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently fixed equipment or furniture with prime coat only before final installation of equipment.
 4. Paint interior surfaces of ducts, where visible through registers or grilles with flat, non-specular black paint.
 5. Paint back sides across panels, and removable or hinged covers to match exposed surfaces.
 6. Finish doors on tops, bottoms, and side edges same as faces.
 7. Sand lightly between each succeeding coat.
 8. No paint shall be applied when the air or surface temperature, as measured in the shade, is above or below that which is recommended by the manufacturer.
 9. Paint shall not be applied to wet or damp surfaces, and shall not be applied in rain, snow, fog, mist or when the surface temperature will be less than 5°F above the dew point.
 10. No paint shall be applied when the air or surface temperature will drop below the manufacturer's recommendation within eight hours after the application of the paint. Dew or moisture condensations should be anticipated, and if such conditions are prevalent, painting shall be delayed until it is certain that the surfaces are dry; further, the day's painting shall be completed well in advance of the probable time of day when the moisture condensation will occur, in order to permit the film the required drying time as specified by the manufacturer prior to the formation of moisture.
 11. Care must be exercised that the coatings are not applied in too heavy a coat above that recommended by the manufacturer and that adequate drying time is permitted between the coats to assure the proper release of solvents.

12. Mixing, thinning, pot life, application procedure, equipment, coverage, curing, re-coating, storage and number of coats shall be in accordance with coating manufacturer's instructions.
 13. Avoid degradation and contamination of blasted surfaces, and avoid between coat contamination. Surfaces contaminated shall be cleaned before applying next coat. Method of cleaning contaminated surface shall be approved by the Owner or Owner's representative.
 14. Each application of material shall be worked into corners, crevices, joints, etc., and distributed evenly over flat surfaces. Spraying techniques that result in uniform wet pattern shall be used and dry spraying should be avoided. Dry spray shall be removed prior to coating being applied.
 15. All bolts, welds, sharp edges, and difficult access areas shall receive a primer brush coat or spray coat prior to primer spray application.
- B. Scheduling Painting: Apply first coat material to surfaces that have been cleaned, pre-treated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration. Allow sufficient time between successive coating to permit proper drying. Do not re-coat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.
- C. Minimum Coating Thickness: Apply materials at not less than manufacturer's recommended spreading rate, to establish a total dry film thickness as recommended by the coating manufacturer.
- D. Prime Coats: Apply prime coat of material which is required to be painted or finished, and which has not been prime coated by others. Re-coat primed and sealed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.
- E. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.
- F. Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes or other surface imperfections.
- G. Completed Work: Match approved samples for color, texture and coverage. Remove, refinish, or repaint work not in compliance with specified requirements.

- H. Workmanship: Workmanship shall be of first class quality. Finish painting shall show no drips, runs, sags, holidays or other defects. The finish coat shall be free from noticeable laps or brush marks. Paint during application shall be continuously stirred and no thinner shall be added after the paint has been mixed. Paint shall be thoroughly worked into all joints, corners, and well brushed out over all surfaces. Should any coat or paint be judged as unsatisfactory, the Contractor shall remove the coat(s) as necessary and repaint at no additional cost to the Owner.

3.8 Clean-up and Protection

- A. Damaged Coatings: Damaged coatings, pinholes, and holidays shall have edges feathered and repaired in accordance with the recommendations of the manufacturer, as approved by the Owner.
- B. All finish coats, including touch up and damage repair coats, shall be applied in a manner which will present a uniform texture and color match appearance.
- C. Unsatisfactory Application: If the item has an improper finish, color or insufficient film thickness, the surface shall be cleaned and top-coated with the specified material to obtain the specified color and coverage. Specific surface preparation information to be secured from the coatings manufacturer and the Owner.
1. All visible areas of chipped, peeled, or abraded paint shall be hand or power-sanded, feathering the edges. The areas shall then be primed and finish coated in accordance with the specifications.
 2. Work shall be free of runs, bridges, shiners, laps or other imperfections. Evidence of these conditions shall be cause for rejection.
 3. Any defects in the coating system shall be repaired by the Contractor per written recommendations of the coating manufacturer.
- D. Guarantee and Anniversary Inspection
1. All work shall be warranted for a period of one year from date of acceptance of the project.
 2. The Owner will notify the Contractor at least 30 days prior to the anniversary date and shall establish a date for the inspection. Any defects in the coating system shall be repaired by the Contractor at no additional cost to the Owner. Should a failure occur to 25% or more of the painted surface, either interior or exterior, the entire surface shall be cleaned and painted in accordance with these specifications.

E. Clean Up

1. All cloths and waste that might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, all staging, scaffolding, and containers shall be removed from the site and/or destroyed in an approved and legal manner. Paint spots, oil or stains upon adjacent surfaces and floors shall be completely removed, and the entire job left clean and acceptable to the Owner.

3.9 Painting Schedule

A. General:

1. Surfaces not to be Painted:
 - a. Face brick
 - b. Concrete floors.
 - c. Items with factory applied final finish.
 - d. Concealed ducts, pipes, and conduit.
 - e. Aluminum, except at wall expansion joints.
 - f. Pre-finished equipment items.
 - g. Gaskets and expansion joints in piping system.
2. Shop primer on materials and products is not considered as primer coat under the painting schedule.

Paint

B. Painting Schedule

| Exposures | Surfaces | System Schedules | | | | |
|-------------------------|------------------------|--|------------------------------------|-----------------------------|----------------|--|
| | | Concrete & Concrete Block Substrate | Non-Ferrous Metals Substrate | Ferrous Metals Substrate | Wood Substrate | Other Substrate |
| Interior | Floors | 134F-1 (light traffic) 134F-2 (heavy traffic) | - | - | - | - |
| | Building Surfaces** | [130] | - | [144] | 121 | Drywall: 160 |
| | Equipment* | - | [-] [114] [or][117] | [144] | - | Galvanized Steel: 154 |
| | Piping* | - | | [144] [145C] [147] | - | Galvanized Steel: 154 [PVC: 174] |
| Exterior Below Grade | Building Surfaces | 336 | -- | 346 | - | - |
| | Piping* | - | -- | 342 | - | - |

* See coating, lining, and/or painting paragraphs in individual piping or equipment Specification Sections.

** See finish schedule for where each type shall be used.

C. Schedule Numbering Guide

| First Number - Exposure | | Second Number - Substrate | | Third Number - Coating Type | | Final Letter | |
|-------------------------|--------------------------------|---------------------------|-----------------------------------|-----------------------------|--------------|--------------|--------------------------|
| 1 | Interior and Weather Protected | 1 | Non-Ferrous Metals | 1 | Alkyd | S | Sewage |
| 2 | Exterior Weather Exposure | 2 | Wood | 2 | Asphaltic | W | Potable Water |
| 3 | Submerged in Potable Water | 3 | Concrete, Concrete Block, Masonry | 4 | Epoxy | F | Floors |
| 4 | - | 4 | Ferrous Metals | 5 | Vinyl | C | Severe Chemical Exposure |
| 5 | Submerged in Wastewater | 5 | Galvanized Ferrous Metals | 6 | Coal Tar | H | Headspace with High H2S |
| 6 | Corrosive Areas | 6 | Drywall | 7 | Polyurethane | | |
| | | 7 | PVC Pipe | 8 | Acrylic | | |
| | | 8 | Fiberglass Reinforced Plastic | 9 | Zinc | | |
| | | 9 | Other | 0 | Latex | | |

D. Material Schedules

| System: 117 | | Surface Preparation: SSPC SP-1 | | | |
|---------------------------------|-----------------------------------|--------------------------------|--|-----------------------|------------------------|
| Type: Epoxy/Polyurethane | | | | | |
| Use: Interior Non-ferrous Metal | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 3.0 | Carboguard 893 SG | Series 66-1211 Epoxoline Primer | Perma-Clean II Primer | Macropoxy 646 FC Epoxy |
| 2nd | 4.0 – 6.0 | Carboguard 893 SG | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| 3rd | 2.0 - 4.0 | Carbothane 134 HG | Series 1074-Color Endura-Shield II | Indurethane 6600 Plus | Acrolon 7300 Urethane |
| System | 10.0 | | | | |

| System: 121 | | Surface Preparation: Clean and Dry | | | |
|---------------------------|-----------------------------------|------------------------------------|-----------------|--------------|----------------------|
| Type: Alkyd EnamelAcrylic | | | | | |
| Use: Interior Wood | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 2.0 to 3.5 | - | 10-99W Primer | AC301 Primer | A-100 Alkyd Primer |
| 2nd | 2.0 to 3.0 | - | 1026 Enduratone | Aquanaut II | ProClassic WB Enamel |
| 3rd | 2.0 to 3.0 | - | 1026 Enduratone | Aquanaut II | ProClassic WB Enamel |

| System: 134 | | Surface Preparation: Clean and Dry | | | |
|-------------------------------------|-----------------------------------|------------------------------------|----------------------------------|-----------------------|-------------------------------|
| Type: Amidoamine or Polyamide Epoxy | | | | | |
| Use: Interior Concrete and Masonry | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1 st | 60-80 SF/Gal. | Carboguard 501 | Series 130 Envirofill | Polyfill Block Filler | Kem Cati-Coat HS Epoxy Filler |
| 2 nd | 4.0 | Carboguard 890 | Series N69 Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| 3 rd | 4.0 | Carboguard 890 | Series N69 Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| System | 8.0 | | | | |

| System: 147 | | Surface Preparation: SSPC SP-10 | | | |
|-----------------------------|-----------------------------------|---------------------------------|--|-----------------------|------------------------|
| Type: Polyurethane | | | | | |
| Use: Interior Ferrous Metal | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 3.0 | Carboguard 893 | Series 66-1211 Epoxoline Primer | Perma-Clean II Primer | Macropoxy 646 FC Epoxy |
| 2nd | 4.0 – 6.0 | Carboguard 893 SG | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| 3rd | 2.0 - 4.0 | Carbothane 134 HG | Series 1074-Color Endura-Shield II | Indurethane 6600 Plus | Acrolon 7300 Urethane |
| System | 10.0 | | | | |

| System: 160 | | Surface Preparation: Clean and Dry | | | |
|-----------------------|-----------------------------------|------------------------------------|---------------------|-----------------------|---|
| Type: Acrylic Latex | | | | | |
| Use: Interior Drywall | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | As recommended by Manufacturer | Sanitile 120 | Series 130 | AC-220 | Block Filler B42KW00046 Heavy Duty Acrylic Block Filler |
| 2nd | 2.0 – 3.0 | Carbocrylic 3359 | Series 6 Tneme-Cryl | AC-210 Acrylic Primer | DTM B66 Series |
| 3rd | 2.0-3.0 | Carbocrylic 3359 | Series 6 Tneme-Cryl | AC-230 or AC-240 | DTM B66 Series |
| System | 4.0-6.0 | | | | |

| System: 174 | | Surface Preparation: Per manufacturer's recommendations | | | |
|--------------------------|-----------------------------------|---|--|-----------------------|------------------------|
| Type: Polyamide Epoxy | | | | | |
| Use: Interior PVC Piping | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 3.0 – 5.0 | Carboguard 893 SG | Series 66-1211 Epoxoline Primer | Perma-Clean II Primer | Macropoxy 646 FC Epoxy |
| 2nd | 4.0 – 6.0 | Carboguard 890 | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| 3rd | 4.0 – 6.0 | Carboguard 890 | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| System | 12.0 | | | | |

| System: 217 | | Surface Preparation: SSPC SP6 | | | |
|---------------------------------|-----------------------------------|-------------------------------|--|------------------------|---------------------|
| Type: Epoxy-Polyurethane | | | | | |
| Use: Exterior Non-ferrous Metal | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 2.5-3.0 | Carboguard 893 SG | Series 66-1211 Epoxoline Primer | Perma-Clean II Primer | Macropoxy 646 Epoxy |
| 2nd | 4.0-5.0 | Carboguard 893 SG | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 Epoxy |
| 3rd | 2.5-3.0 | Carbothane 133 HB | Series 1074-Color Endura Shield II | Indurathane 6600 PlusI | Acrolon 7300 |
| System | 9.0-11.0 | | | | |

| System: 221 | | Surface Preparation: Per Manufacturer's Recommendation | | | |
|--------------------|-----------------------------------|--|------------------------------|-------------|------------------------|
| Type: Alkyd | | | | | |
| Use: Exterior Wood | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1st | 2.0 | - | Series 10-99W Primer | AC301 | A-100 Alkyd Primer |
| 2nd | 1.5 – 2.0 | - | Series 1028-Color Enduratone | Aquanaut II | Industrial Enamel B-54 |
| 3rd | 1.5 – 2.0 | - | Series 1028-Color Enduratone | Aquanaut II | Industrial Enamel B-54 |
| System | 5.0 | | | | |

| | | | | | |
|------------------------------------|--|--|--|--|--|
| System: 234 | | Surface Preparation: CC-3 | | | |
| Type: Epoxy | | Note: Concrete shall be at least 28 days old before any of these coatings are applied. | | | |
| Use: Exterior Concrete and Masonry | | | | | |

| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
|--------|-----------------------------------|--------------------|-------------------------|---------|-----------------------|
| 1st | 60-80 SF/Gal. | Sanitile 100 | Series 130 Envirofill | AC-220 | Loxon Primer |
| 2nd | 8.0 | Flexxide Elastomer | Series 156 Enviro-Crete | AC-403 | Loxon Masonry Coating |
| 3rd | 8.0 | Flexxide Elastomer | Series 156 Enviro-Crete | AC-403 | Loxon Masonry Coating |
| System | 16.0 | | | | |

| | | | | | |
|-------------------------------|--|---------------------------------|--|--|--|
| System: 247 | | Surface Preparation: SSPC SP-10 | | | |
| Type: Zinc-Epoxy-Polyurethane | | | | | |
| Use: Exterior Ferrous Metal | | | | | |

| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
|--------|-----------------------------------|-------------------|--------------------------------------|-----------------------|-------------------------------|
| 1st | 3.0-3.5 | Carbozinc 859 | Series 90-97 Tneme-Zinc | Indurazinc MC67 | Zinc-Clad IV or Zinc-Clad III |
| 2nd | 6.0-7.0 | Carboguard 890 | Series N69-Color Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 Epoxy |
| 3rd | 2.5-3.0 | Carbothane 133 HB | Series 1074-Color EnduraShield II | Indurathane 6600 Plus | Acrolon 7300 |
| System | 11.5-16.5 | | | | |

| | | | | | |
|--------------------------|--|--|--|--|--|
| System: 257 | | Surface Preparation: In accordance with manufacturer's recommendations | | | |
| Type: Epoxy Polyurethane | | | | | |
| Use: Galvanized Steel | | | | | |

| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
|-----------------|-----------------------------------|----------------|---|-----------------------|------------------------|
| 1 st | 2.5-3.0 | Carboguard 635 | Series 27 Typoxy | Vinyl Wash Primer | Macropoxy 646 FC Epoxy |
| 2 nd | 4.0-5.0 | Carboguard 890 | Series N69-Color Hi-Build Epoxoline II | Perma-Clean II Epoxy | Macropoxy 646 FC Epoxy |
| 3 rd | 2.5-3.0 | Carbothane 133 | Series 1074-Color Endura-Shield II | Indurathane 6600 Plus | Acrolon 7300 |
| System | 9.0-11.0 | | | | |

| System: 434W | | Surface Preparation: CC-3 | | | |
|---|-----------------------------------|-----------------------------|--------------------------------------|-------------|-------------------------|
| Type: Epoxy All coatings provided under this system shall be NSF 61 approved. | | | | | |
| Use: Submerged Concrete – Potable Water | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1 st | 4.0 - 6.0 | Carboguard 561/561 LT Beige | Series N140-1255 Pota-Pox Plus Beige | PE-54 Epoxy | Macropoxy 646 NSF Epoxy |
| 2 nd | 4.0 - 6.0 | Carboguard 561/561 LT White | Series N140-AA90 Pota-Pox Plus White | PE-54 Epoxy | Macropoxy 646 NSF Epoxy |
| 3 rd | 2/0 – 3.0 | Carboguard 561/561 LT White | Series N140-AA90 Pota-Pox Plus White | PE-54 Epoxy | Macropoxy 646 NSF Epoxy |
| System | 10.0 | | | | |

NOTE: Each coat shall be of a different color so that complete coverage can be verified.

| System: 444W | | Surface Preparation: SP-10 | | | |
|--|-----------------------------------|----------------------------|---|-------------|-------------------------|
| Type: Epoxy All coatings provided under this system shall be NSF 61 approved | | | | | |
| Use: Submerged Ferrous Metal – Potable Water | | | | | |
| Coat | Minimum Dry Film Thickness (Mils) | Carboline | Tnemec | Induron | Sherwin Williams |
| 1 st | 3.0 | Carboguard 891 Red | Series N140-1211 Pota-Pox Plus Red | PE-70 Epoxy | Macropoxy 646 NSF Epoxy |
| 2 nd | 4.0 - 6.0 | Carboguard 891 Gray | Series N140-1255 Pota-Pox Plus Beige | PE-70 Epoxy | Macropoxy 646 NSF Epoxy |
| 3 rd | 4.0 – 6.0 | Carboguard 891 White | Series N140-WH02 Pota-Pox Plus Tank White | PE-70 Epoxy | Macropoxy 646 NSF Epoxy |
| System | 12.0 | | | | |

NOTE: Each coat shall be of a different color so that complete coverage can be verified.

END OF SECTION

Part 1 General

1.1 Related Documents

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 26.

1.2 Summary

- A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:
 - 1. Submittals.
 - 2. Coordination drawings.
 - 3. Record documents.
 - 4. Maintenance manuals.
 - 5. Rough-ins.
 - 6. Electrical installations.
 - 7. Cutting and patching.
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Section 26 05 00 for materials and methods common to the remainder of Division 26, plus general related specifications including:
 - a. Access to electrical installations.
 - b. Excavation for electrical installations within the building boundaries and from building to utility connections.

1.3 Submittals

- A. General: Follow the procedures specified in Section 01 33 00.

Basic Electrical Requirements

- B. Product data shall be submitted in a notebook size three- ring binder. Each binder shall have a tab for each specification section requiring a submittal. Each section shall include a summary of items included along with application criteria. Notebooks, tabs and summary sheets shall accompany the first submittal. Subsequent submittals may be submitted, three-hole punched, for insertion into the appropriate binder section. DO NOT mix submittals of multiple sections under a single tab, even if from the same manufacturer or service.
- C. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.
 - 1. Shop Drawings - Initial Submittal: 2 additional blue- or black-line prints.
 - 2. Shop Drawings - Final Submittal: 2 additional blue- or black-line prints.
 - 3. Product Data: 2 additional copy of each item.
 - 4. Samples: 1 additional as a set.
- D. Additional copies may be required by individual sections of these specifications.
- E. Submittal schedule shall allow sufficient time for A/E's review and resubmittal if so marked without impacting the project schedule for work of other trades.

1.4 Record Documents

- A. Prepare record documents in accordance with the requirements in Section 01 78 39. In addition to the requirements specified in Division 1, indicate installed conditions for:
 - 1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 - 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 Maintenance Manuals

- A. Prepare maintenance manuals in accordance with Section 01 78 23. In addition to the requirements specified in Division 1, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.6 Delivery, Storage, and Handling

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

Part 2 Products

2.1 Electrical Materials

- A. Provide all materials used in this work, unless otherwise indicated, that are new and free from flaws or imperfections.
- B. All electrical materials shall be UL listed or labeled.

Part 3 Execution

3.1 Rough-In

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Division 2 through 26 for rough-in requirements.

3.2 Electrical Installations

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
 1. Coordinate electrical systems, equipment, and materials installation with other building components. Electrical drawings are generally of a diagrammatic nature. Except where dimensioned locations are shown, plan and coordinate the work to eliminate interferences with other trades. Provide all necessary raceway offsets, fittings, and boxes; adjust all fixture and equipment locations and provide all supporting materials required for a planned, coordinated and neat installation. Where interferences occur, the Owner's authorized representative will decide which items must be relocated regardless of which was installed first.
 2. Verify all dimensions by field measurements.

3. Provide chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Owner's Representative.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
12. Install access panels or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Section 26 05 00 "Basic Electrical Materials and Methods."

3.3 Cutting and Patching

- A. General: Perform cutting and patching in accordance with the following requirements:
 1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Uncover Work to provide for installation of ill-timed Work.

- b. Remove and replace defective Work.
 - c. Remove and replace Work not conforming to requirements of the Contract Documents.
 - d. Remove samples of installed Work as specified for testing.
 - e. Install equipment and materials in existing structures.
 - f. Upon instructions from the Owner's Representative, uncover and restore Work to provide for Owner's Representative's observation of concealed Work.
2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
 6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
 7. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 Painting

- A. Paint exposed electrical equipment and materials. Limit painting of factory-finished equipment to touching up unless indicated otherwise.

3.5 Testing

- A. In addition to testing required under these specifications, the Owner reserves the right to conduct independent acceptance tests on any or all portions of the installation. Acceptance tests will be to determine fulfillment of contract requirements and will be conducted in the presence of an authorized representative of the Contractor, Owner, and the Engineer. The Contractor shall correct all deficiencies discovered during acceptance testing.

END OF SECTION

Part 1 General

1.1 Related Documents

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements specified in Section 26 01 00 apply to this Section.

1.2 Summary

- A. This Section includes limited scope general construction materials and methods for application with electrical installations as follows:
 - 1. Selective Demolition Including:
 - a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
 - b. Dismantling electrical materials and equipment made obsolete by these installations.
 - 2. Wood grounds, mailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
 - 3. Miscellaneous metals for support of electrical materials and equipment.
 - 4. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 5. Excavation for underground utilities and services, including underground raceways, vaults, and equipment.
 - 6. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.3 Submittals

- A. General: Submit the following in accordance with Conditions of Contract and Section 01 33 00.
- B. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.
- C. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of electrical service, and details for dust and noise control.

1. Coordinate sequencing with construction phasing, work by others, and Owner occupancy specified in Section 01 11 00.
- D. Product Data for the Following Products:
 1. Access panels, doors, and joint sealers.
- E. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for electrical materials and equipment.
- F. Coordination drawings for access panel and door locations in accordance with Section 26 01 00.

1.4 Quality Assurance

- A. Installer Qualifications: Engage an experienced Installer for the installation and application joint sealers.
- B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
- C. Fire resistance ratings where a fire resistance classification is indicated, provide equipment and assemblies listed in the UL "Building Materials Directory" for rating shown.
- D. Provide UL label on each fire rated item.

1.5 Delivery, Storage, and Handling

- A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.6 Project Conditions

- A. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.
- B. Conditions Affecting Selective Demolition: The following project conditions apply:
 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.

2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
3. Conditions Affecting Excavations: The following project conditions apply:
 - a. Maintain and protect existing building services which transit the area affected by selective demolition.
 - b. Protect structures utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
 - c. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
 - d. Remove existing underground utilities indicated to be removed.
 - 1) Uncharted or Incorrectly Charted Utilities: Contact utility Owner immediately for instructions.
 - 2) Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner's Representative prior to utility interruption.

1.7 Sequence and Scheduling

- A. Coordinate the shut-off and disconnection of electrical service with the Owner.
- B. Notify the Owner's Representative at least 5 days prior to commencing demolition operations.
- C. Perform demolition in phases as indicated.

Part 2 Products

2.1 Miscellaneous Metals

- A. Steel plates, shapes, bars, and bar grating: ASTM A 36.
- B. Cold-Formed Steel Tubing: ASTM A 500.
- C. Hot-Rolled Steel Tubing: ASTM A 501.
- D. Steel Pipe: ASTM A 53, Schedule 40, welded.
- E. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.

- F. Fasteners: Zinc-coated, type, grade, and class as required.

2.2 Fire Resistant Joint Sealers

A. Manufacturers

1. Hilti Construction Chemicals, Inc.
2. Dow Corning Corporation
3. 3M, Construction Markets

B. Materials

1. Firestopping Material: Single or multiple component silicone elastomeric compound as follows:
 - a. Firestop Sealant: An adhesive, one part, silicone based, elastomeric sealant.
 - 1) Hilti: CS 240 firestop sealant
 - 2) Dow Corning: Firestop sealant
 - 3) 3M: Fire barrier CP 25WB caulk
 - b. Intumescent Wrap: An aluminum foil backed intumescent strip for plastic, insulated pipe, or other combustible penetrating items.
 - 1) Hilti: CS 2420 intumescent wrap
 - 2) Dow Corning: Fire stop intumescent wrap, Strip 2002
 - 3) 3M: 3M Brand Fire Barrier FS-195 Wrap/Strip

2.3 Miscellaneous Lumber

- A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 common or standard grade boards complying with WCLIB OR AWPA rules, or number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.
- B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less than 15/32 inches.

2.4 Joint Sealers

- A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

- B. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.

Part 3 Execution

3.1 Examination

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 Preparation for Joint Sealers

- A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.
- B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.3 Erection of Wood Supports and Anchorage

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.4 Application of Joint Sealers

- A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
- B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

- C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

END OF SECTION

Low-Voltage Electrical Power Conductors and Cables**Part 1 General****1.1 Summary****A. Section Includes:**

1. Building wires and cables rated 2000 V and less.
2. Wires and cables for PV systems rated 2000 V and less.
3. Connectors, splices, and terminations rated 2000 V and less.

B. Related Requirements:

1. Section 26 05 23 - Control-Voltage Electrical Power Cables for control systems communications cables and Classes 1, 2, and 3 control cables.

1.2 Definitions

- A. VFC: Variable-frequency controller.

1.3 Action Submittals

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

1.4 Informational Submittals

- A. Field quality-control reports.

Part 2 Products**2.1 Conductors and Cables**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire Company.
 2. American Bare Conductor.
 3. Belden Inc.
 4. Cerro Wire L.L.C.
 5. General Cable.

6. Lapp USA.
 7. Service Wire Co.
 8. Southwire Company.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable used in VFC circuits.
- E. Conductors: Stranded copper, complying with NEMA WC 70/ICEA S-95-658.
1. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2 and Type XHHW-2 as required by the Execution paragraphs here-in.
 2. Provide self-lubricated (low friction) version of thermoplastic or thermoset insulation.
- F. Tray Cable
1. Description: ANSI/NFPA 70, Type TC, multi-conductor, suitable for use in tray, conduit, or duct.
 2. Conductor: NEMA B stranded copper.
 3. Insulation Voltage Rating: 600 volts.
 4. Insulation Temperature Ratings: 75 degrees C.
 5. Insulation Material: Type THWN for 10 AWG and larger; Type XHHW for 8 AWG and smaller.
 6. Jacket Material: PVC.
 7. Construction: Multi-conductor with 50% (3 minimum) integral ground conductors.
- G. Metal Clad Cable
1. Description: ANSI/NFPA 70, Type MC, suitable for installation in cable tray, conduit, trench or wireway, indoors, outdoors, or underground.
 2. Conductor: NEMA B stranded copper.

3. Configuration: 3 or 4 conductor with ground as indicated. Provide 50% (3 minimum) bare copper grounding conductors.
 4. Insulation Voltage Rating: 600 volts.
 5. Insulation Temperature Rating: 90 degrees C.
 6. Insulation Material: Type XHHW.
 7. Armor Material: Armor.
 8. Armor Design: Interlocked aluminum armor.
 9. Jacket: Black PVC.
- H. VFC Cable:
1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
 2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 Connectors and Splices

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Power Systems, Inc.
 2. Ideal Industries, Inc.
 3. IlSCO; a branch of Bardes Corporation.
 4. NSi Industries LLC.
 5. O-Z/Gedney; a brand of the EGS Electrical Group.
 6. 3M; Electrical Markets Division.
 7. Thomas & Betts.
- B. Substitutions: In accordance with Section 01 25 00 - Substitution Procedures.
- C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
- D. Wiring Connectors

1. Mechanical Connectors:
 - a. For conductor sizes No. 8 AWG and larger, make all splices, taps and terminal connections using UL listed cast and machined high-conductivity copper alloy connectors of the circular clamp type with multiple socket-head cap screws manufactured by Thomas & Betts. Except where insulated covers are provided, fill voids and irregularities on connections with "Scotchfil" insulation putty and cover neatly with 2 half-lapped layers of Scotch No. 88 insulating tape and one half-lapped layer of friction tape.
2. Spring Wire Connectors:
 - a. 3-M Company, Model "Scotch-lok" or "Hyflex".
 - b. Ideal Industries, Model "Wingnut".
3. Strap-Screw Terminal Connectors: Use ring-tongue or locking fork lugs on all strap-screw device terminals; do not exceed 3 lugs per terminal. Use crimping tools which are specifically designed for the application.
4. Armored Cable Connectors:
 - a. O-Z, Model "PG" Armor terminator.

Part 3 Execution

3.1 Conductor Material Applications

- A. Feeders: NEMA Class B stranded copper.
- B. Branch Circuits: Copper; stranded.
- C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 Conductor Insulation and Multiconductor Cable Applications and Wiring Methods

- A. Service Entrance: Type XHHW-2, single conductors in raceway unless otherwise indicated.
- B. Feeders (Larger than No. 4 AWG): Type XHHW-2, single conductors in raceway, 90°C; wet location rated 75°C.
- C. Feeders (4 AWG and Smaller): Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

- E. Feeders in Cable Tray: Metal-clad cable, Type MC.
- F. Branch Circuits: Type THHN/THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- H. Branch Circuits in Cable Tray: Metal-clad cable, Type MC.
- I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- J. VFC Output Circuits: Type TC-ER cable with braided shield.
- K. DC Circuits: Type W or locomotive cable. Extremely flexible, outdoor and cable tray rated in raceway.

3.3 Installation of Conductors and Cables

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 - Raceways and Boxes for Electrical Systems prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- F. Support cables according to Section 26 05 29 - Hangers and Supports for Electrical Systems.
- G. Pull all conductors into raceway at same time.
- H. Protect exposed cable from damage.
- I. Use suitable cable fittings and connectors.
- J. Neatly train and lace wiring inside boxes, equipment, and panelboards. Lace wiring in cable tray at no more than 10 foot intervals using T&B "Ty-Raps" of appropriate size and type.
- K. Clean conductor surfaces before installing lugs and connectors.

- L. Use mechanical connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor. Taps shall only be permitted where specifically indicated on the Drawings.
- M. Use insulated spring wire connectors with plastic caps for copper conductor splices, 10 AWG and smaller.
- N. Leave slack in wire and cable at all termination and junction points.
- O. Do not splice feeders unless specifically approved by the Owner's Representative and Engineer. When approved make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
- P. Use irreversible compression connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor. Cover connection with cold shrink rubber sleeve.

3.4 Connections

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack. Terminate stranded conductors with compression locking fork terminals, and then secure the terminal under the side screw.

3.5 Identification

- A. Identify and color-code conductors and cables according to Section 26 05 53 - Identification for Electrical Systems. For cables smaller than No. 4 AWG use colored insulation. For cables No. 4 AWG and larger, black insulation with colored marking tape may be used.
- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 Sleeve and Sleeve-Seal Installation For Electrical Penetrations

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling.

3.7 Firestopping

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 26 05 00 - Basic Electrical Materials and Methods. Bond sleeves to ground with code sized bonding jumper.

3.8 Field Quality Control

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of all feeders and any branch circuits 100A and greater. Refer to Section 26 05 01 - Electrical Testing for additional requirements.
- B. Perform the following tests and inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors on circuits 100A and greater for compliance with requirements.
 - 2. Perform each of the following visual and electrical tests in accordance with NETA ATS and Section 26 05 01 - Electrical Testing:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) Calibrated torque wrench.
 - c. Inspect compression applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor with respect to ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
 - 3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each connection in conductors No. 4 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

- a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- C. Cables will be considered defective if they do not pass tests and inspections and shall be replaced completely.
- D. Prepare test and inspection reports to record the following:
1. Procedures used.
 2. Results that comply with requirements.
 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Multimode optical-fiber cabling.
 - 2. UTP cabling.
 - 3. RS-485 cabling.
 - 4. Low-voltage control cabling.
 - 5. Control-circuit conductors.
 - 6. Identification products.

1.2 Definitions

- A. EMI: Electromagnetic interference.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- D. RCDD: Registered Communications Distribution Designer.
- E. UTP: Unshielded twisted pair.

1.3 Action Submittals

- A. Product Data: For each type of product.

1.4 Informational Submittals

- A. Field quality-control reports.

1.5 Quality Assurance

- A. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

Part 2 Products

2.1 System Description

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 Performance Requirements

- A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - 1. Flame Travel Distance: 60 inches or less.
 - 2. Peak Optical Smoke Density: 0.5 or less.
 - 3. Average Optical Smoke Density: 0.15 or less.
- B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 Backboards

- A. In addition to requirements in Division 6 sections and Architectural drawings, provide the following:
 - 1. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches.
 - 2. Painting: Paint plywood on all sides and edges with eggshell, white, alkyd paint.

2.4 Optical-Fiber Cable

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. AMP NETCONNECT; a Tyco Electronics brand; a TE Connectivity Ltd. company.
 - 2. Belden Inc.
 - 3. Berk-Tek; a Nexans company.
 - 4. CommScope, Inc.

5. Corning Cable Systems.
 6. General Cable; General Cable Corporation.
 7. Siemon Co. (The).
 8. Tyco Electronics Corporation; a TE Connectivity Ltd. company.
- B. Description: Single mode, 50/125-micrometer, 12-fiber, nonconductive, tight-buffer, optical-fiber cable unless otherwise indicated.
1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA-568-B.3 for performance specifications.
 3. Comply with TIA-492AAAA-A for detailed specifications.
 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 - b. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - c. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 5. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
 6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
 7. Conductive Cable shall be aluminum armored type.
- C. Jacket:
1. Jacket Color: Aqua for 50/125-micrometer cable.
 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-B.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.5 Optical-Fiber Cable Hardware

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Berk-Tek; a Nexans company.
 3. Corning Cable Systems.
 4. Dynacom Corporation.
 5. Hubbell Premise Wiring.
 6. Optical Connectivity Solutions Division.
 7. Panduit Corp.
 8. Siemon Co. (The).
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.
- D. Cable Connecting Hardware:
 1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2, TIA-604-3-A, and TIA/EIA-604-12. Comply with TIA-568-B.3.
 2. Quick-connect, Type LC connectors. Insertion loss of not more than 0.75 dB.

2.6 UTP Cable

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Alpha Wire Company; a division of Belden Inc.
 2. Belden Inc.
 3. CommScope, Inc.
 4. Draka Cableteq USA.
 5. Genesis Cable Products; Honeywell International, Inc.

6. Mohawk; a division of Belden Inc.
 7. Siemon Company (The).
 8. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- B. Description: 100-ohm, four-pair UTP and 24-pair UTP, formed into four-pair binder groups with no overall jacket.
1. Comply with ICEA S-102-700 for mechanical properties of Category 6 cables.
 2. Comply with TIA-568-C.1 for performance specifications.
 3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - b. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - c. Communications, General Purpose: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.7 UTP Cable Hardware

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. American Technology Systems Industries, Inc.
3. AMP NETCONNECT; a Tyco Electronics brand; a TE Connectivity Ltd. company.
4. Dynacom Corporation.
5. Hubbell Premise Wiring.
6. Leviton Manufacturing Co., Inc.
7. Panduit Corp.

8. Siemon Co. (The).
9. Siecor.
- B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- C. Connecting Blocks: 110-style IDC for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
- D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.
- E. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.
- F. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.
 1. Patch cords shall have color-coded boots for circuit identification.
- G. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate. Outdoors and in areas subject to open water and damp locations; use wet location covered outlets as indicated.
- H. Faceplates:
 1. Metal Faceplate: Stainless steel, complying with requirements in Section 26 27 26 - Wiring Devices.
 2. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.
 - a. Flush-mounted jacks, positioning the cord at a 45-degree angle.
- I. Legend:
 1. Machine printed, in the field, using adhesive-tape label.

2.8 Twin-Axial Data Highway Cable

- A. Standard Cable: NFPA 70, Type CM.
1. Paired, pairs as noted on drawings, No. 20 AWG, stranded (7x28) tinned-copper conductors.
 2. Polypropylene insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. PVC jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 6. Flame Resistance: Comply with UL 1685.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, pairs as noted on drawings, No. 20 AWG, stranded (7x28) tinned--copper conductors.
 2. Plastic insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. Plastic jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.

2.9 RS-485 Cable

- A. Standard Cable: NFPA 70, Type CMG.
1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 2. PVC insulation.
 3. Unshielded.
 4. PVC jacket.
 5. Flame Resistance: Comply with UL 1685.

- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Flame Resistance: NFPA 262.

2.10 Low-Voltage Control Cable

- A. Paired Cable: NFPA 70, Type CMG.
 - 1. One-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1685.
- B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - 1. One-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with NFPA 262.

2.11 Control-Circuit Conductors

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Encore Wire Corporation.
 - 2. General Cable; General Cable Corporation.
 - 3. Southwire Company.
 - 4. Lapp.

5. Belden.
 6. Alpha Wire.
 7. Anixter.
- B. Class 1 Control Circuits: Stranded copper, Type RHW-2, in raceway, complying with UL 44. No 14 AWG unless otherwise indicated.
 - C. Class 2 Control Circuits: Stranded copper, tray cable (TC), in cable tray or raceway, complying with UL 44.
 - D. Class 3 Remote-Control and Signal Circuits: Stranded copper, power-limited tray cable (PLTC), in cable tray or raceway, complying with UL 83.
 - E. Multi-conductor control cables shall have an overall XLPE jacket and XL-CPE insulation on stranded copper conductors. Conductor insulation shall be numbered "1 to N" and colored per ICEA S-73-532 Table E-2. Cables shall be listed for 90% operation wet or dry. Cables shall be listed for cable tray applications (TC) meeting VW-1.

2.12 Source Quality Control

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP cables according to TIA-568-C.2.
- C. Factory test optical-fiber cables according to TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

Part 3 Execution

3.1 Examination

- A. Test cables on receipt at Project site.
 1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
 2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
 3. Test each pair of UTP cable for open and short circuits.

3.2 Installation of Raceways and Boxes

- A. Comply with requirements in Section 26 05 33 - Raceways and Boxes for Electrical Systems for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
 - 1. Outlet boxes shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
 - 2. Flexible metal conduit shall not be used.
- B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
- C. Install manufactured conduit sweeps and long-radius elbows if possible.
- D. Raceway Installation in Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard if entering the room from overhead.
 - 4. Extend conduits 6 inches above finished floor unless otherwise indicated.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 Installation of Conductors and Cables

- A. Comply with NECA 1 and NFPA 70.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C Series of standards.
 - 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
 - 3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

4. Cables may not be spliced.
 5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
 9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
 10. Support: Do not allow cables to lay on removable ceiling tiles.
 11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
- C. UTP Cable Installation:
1. Comply with TIA-568-C.2.
 2. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.
- D. Installation of Control-Circuit Conductors:
1. Install wiring in raceways. Comply with requirements specified in Section 26 05 33 - Raceways and Boxes for Electrical Systems.
- E. Optical-Fiber Cable Installation:
1. Comply with TIA-568-C.3.
 2. Terminate cable on connecting hardware that is rack or cabinet mounted.
- F. Open-Cable Installation: NOT PERMITTED
- G. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.

2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 10 feet of cable in a coil not less than 12 inches in diameter.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 Removal of Conductors and Cables

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.5 Control-Circuit Conductors

- A. Minimum Conductor Sizes unless otherwise indicated on Drawing or directed by equipment manufacturers:
 1. Class 1 remote-control and signal circuits; No 14 AWG.
 2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
 3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 16 AWG.

3.6 Firestopping

- A. Comply with requirements in Section 26 05 00 - Basic Electrical Materials, for penetration firestopping.
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 Grounding

- A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems.

3.8 Identification

- A. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.9 Field Quality Control

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Visually inspect UTP and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 4. Optical-Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - 2) Attenuation test results for links shall be less than 2.0 dB according to equation in TIA-568-C.0.
- D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

Grounding and Bonding for Electrical Systems

Part 1 General

1.1 Summary

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.2 Action Submittals

- A. Product Data: For each type of product indicated.

1.3 Informational Submittals

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
- B. Field quality-control reports.

1.4 Quality Assurance

- A. Testing Agency Qualifications: Refer to Section 26 05 01 - Electrical Testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

Part 2 Products

2.1 Manufacturers

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Fushi Copperweld Inc.
4. Harger Lightning & Grounding.
5. ILSCO.
6. O-Z/Gedney; a brand of Emerson Industrial Automation.
7. Robbins Lightning, Inc.

2.2 System Description

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 Conductors

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 1. Stranded Conductors: ASTM B 8.
 2. Tinned Conductors: ASTM B 33.
 3. Bonding Conductor: No. 4 AWG, stranded conductor.
 4. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart unless otherwise indicated. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 Connectors

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- E. Irreversible Compression Connectors: Burndy Hy-Ground or equivalent by T&B.

2.5 Grounding Electrodes

- A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet unless otherwise indicated.

Part 3 Execution

3.1 Applications

- A. Conductors: Install stranded copper conductors unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 4/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors or irreversible compression connector except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

5. Connections to Rebar: Listed compression clamp.
6. Bonding connector where steel raceway is not effectively bonded: OZ-Gedney #GH-B or equivalent.

3.2 Grounding at the Service

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 Grounding Separately Derived Systems

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 Grounding Underground Distribution System Components

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches (unless utility company has more stringent requirements): Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 Equipment Grounding

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 Installation

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems, and shall be at least 12 inches deep, with cover. Provide "Ground" legend on cover of test well.
1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart, unless otherwise indicated.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building or area or item indicated.
 - 1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 36 inches from building's foundation and not less than 24 inches below rough grade.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4/0 AWG.
 - 1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 - 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
- K. Make grounding connections to building steel by exothermic weld unless specifically indicated otherwise and approved.
- L. Cable trays shall be grounded with a #4/0 bare stranded copper grounding conductor bonded to each section.
- M. As far as practical, grounding cable shall be continuous, without joints or splices throughout its length.
- N. Bolted grounding connections shall use corrosion-resistant materials.
- O. Exposed ground cable shall be protected against mechanical injury. Ground cable passing through concrete floor slabs or through walls shall be protected by schedule 80 rigid PVC, rigid conduit sleeves projecting 6 inches above and below floor slab.
- P. All electrical equipment shall be grounded by direct connection to the copper grounding network. Conduits or building structural steel are unacceptable as adequate paths to ground.

- Q. Conduits shall be grounded to the metal framework of the switchgear motor control centers, boxes and equipment where they terminate. Conduits running from cable trays shall be bonded to the trays. Conduits terminating at locations other than equipment shall also be connected to ground.

3.7 Field Quality Control

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections in accordance with Section 26 05 01 - Electrical Testing.
- B. Perform tests and inspections.
- C. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, or at individual ground rods where test wells are not specified. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 4. Prepare Record Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Substations and Pad-Mounted Equipment: 5 ohms.
 5. Manhole Grounds: 10 ohms.
- G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 Action Submittals

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Hangers.
 - b. Steel slotted support systems.
 - c. Trapeze hangers.
 - d. Clamps.
 - 2. Include rated capacities and furnished specialties and accessories.

1.3 Informational Submittals

- A. Welding certificates.

1.4 Quality Assurance

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

Part 2 Products

2.1 Performance Requirements

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D 635.

2.2 Support, Anchorage, and Attachment Components

- A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Haydon Corporation.
 - f. Thomas & Betts Corporation; a member of the ABB Group.
 - g. Unistrut; an Atkore International company.
 2. Material: Stainless steel.
 3. Channel Width: 1-5/8 inches.
 4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 6. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Stainless-steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: 316 Stainless-steel springhead type.
7. Hanger Rods: Threaded 316 stainless steel in plant and pump station process areas and galvanized steel in non-process spaces.

2.3 Fabricated Metal Equipment Support Assemblies

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

- B. Materials: Comply with requirements in Division 05 Sections for steel shapes and plates.

Part 3 Execution

3.1 Application

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 26 05 33 - Raceways and Boxes for Electrical Systems.
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in Table at the end of this Section, where Table lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 3/8 inch in diameter.
- D. Multiple Raceways: Install trapeze-type supports fabricated with stainless steel slotted support system in process areas or galvanized steel in non-process areas, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 Support Installation

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
 - 1. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
 - 2. Install individual and multiple raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 3. Support parallel runs of horizontal raceways together on trapeze-type hangers.

4. Support individual horizontal raceways by separate pipe hangers.
 5. Space supports for raceways in accordance with Table 1 of this Section. Space supports for raceway types not covered by the above in accordance with NEC.
 6. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported, and raceway terminals are not made with chase nipples or threadless box connectors.
 7. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
- B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 Installation of Fabricated Metal Supports

- A. Comply with installation requirements in Division 05 Sections for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 Concrete Bases

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03.
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 Painting

- A. Touchup: Clean field welds and abraded areas of paint. Paint exposed areas immediately after erecting hangers and supports. Comply with SSPC-PA 1 requirements for touching up painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

SPACING FOR RACEWAY SUPPORTS

| Raceway Size | Location | Spacing (Feet) | | |
|---------------------------------------|------------|----------------|-----|-----|
| | | RMC/IMC | EMT | RNC |
| 1/2", 3/4", 1" | Horizontal | 8 | 5 | 3 |
| 1/2", 3/4", 1", 1-1/4", 1-1/2", 2" | Vertical | 10 | 8 | 5 |
| 1-1/4", 1-1/2", 2" | Horizontal | 10 | 8 | 5 |
| 3", 4" | Horizontal | 15 | 10 | 10 |
| 3", 4" | Vertical | 20 | 10 | 10 |
| Cable Tray | Horizontal | 10' | | |
| Cable Tray | Vertical | 20" | | |

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 Definitions

- A. GRC: Galvanized rigid steel conduit.
- B. IMC: Intermediate metal conduit.

1.3 Action Submittals

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.4 Informational Submittals

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 1. Structural members in paths of conduit groups with common supports.
 2. Process, HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

3. Verify that field measurements are as shown on Drawings. Confirm with final equipment shop drawings.
 4. Verify routing and termination locations of conduit prior to rough-in.
 5. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.
- B. Seismic Qualification Certificates (where required): For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- C. Source quality-control reports.

Part 2 Products

2.1 Metal Conduits, Tubing, And Fittings

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a part of Atkore International.
 3. Anamet Electrical, Inc.
 4. Electri-Flex Company.
 5. O-Z/Gedney; a brand of Emerson Industrial Automation.
 6. Republic Conduit.
 7. Robroy Industries.
 8. Thomas & Betts Corporation, A Member of the ABB Group.
 9. Western Tube and Conduit Corporation.

-
10. Wheatland Tube Company.
 - B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - C. GRC: Comply with ANSI C80.1 and UL 6.
 - D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 1. Comply with NEMA RN 1.
 2. The PVC coated galvanized rigid conduit must be UL Listed and ETL Verified. Both the PVC and Zinc coating must have been investigated by UL as providing primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to plastic coating must be UL listed. All conduit and fittings must be new, unused material.
 3. The PVC coated galvanized rigid conduit must be ETL Verified to the Intertek ETL High Temperature H2O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit must bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.
 4. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.
 5. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation.
 6. Form 8 Condulets shall have a V-Seal tongue-in-groove gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours shall be available. Form 8 Condulets shall be supplied with plastic encapsulated stainless steel cover screws.
 7. Urethane coating of nominal 2 mil thickness shall be uniformly and consistently applied to the interior of all conduit and fittings. Conduit or fittings with thin or no coating shall be unacceptable.
 8. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).

9. All female threads on fittings and couplings shall be protected by urethane coating.
 10. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.
- E. FMC: Comply with UL 1; zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B; material to match conduit.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Expansion Fittings: Steel, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 3. Steel Fittings (Provide similar series fittings for other materials): For rigid steel conduit provide zinc coated, cast malleable, ferrous metal, threaded fittings, Appleton "form 35 Unilets" or Crouse-Hinds "Form 7 Condulets". Provide a neoprene cover gasket on each fitting installed outdoors.
 4. "Mogul Fittings": Provide "Mogul" size fittings for conduit larger than 2 inches.
 5. Grounding Bushings: Provide Appleton Type "GIB" Crouse-Hinds Type "GB" or Thomas & Betts 3800 Series threaded, grounding type insulated, metallic bushing, in combination with one exterior and one interior locknut, on each rigid conduit terminating in sheet metal box, cabinet, trough, gutter or wireway.
 6. Sealing Bushings: Provide O.Z. compound bushing or sealing bushing on each conduit entering the building from outside underground and on each conduit passing from one space into another which is normally at a lower temperature.
 7. Hubs: Provide Appleton "HUB" or "HUB-U" Series or Thomas & Betts "370" Series hub on each conduit terminating in a box or cabinet exposed to the weather.
 8. Unions: Where conduit unions are necessary, provide Appleton Type "EC" or Thomas & Betts "Erickson coupling".
 9. Fire Barriers: Provide barriers in all openings and around all penetrations in fire-rated walls and floors. Seal with fireproof sealant in accordance with Section 26 05 00 "Basic Electrical Materials and Methods and Division 07 as applicable.

- H. Joint Compound for GRC or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 Nonmetallic Conduits And Fittings

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CANTEX INC.
 - 2. CertainTeed Corporation.
 - 3. Condux International, Inc.
 - 4. Kraloy.
 - 5. Lamson & Sessions.
 - 6. RACO; Hubbell.
 - 7. Thomas & Betts Corporation, A Member of the ABB Group.
- B. Listing and Labeling: Nonmetallic conduits and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 Metal Wireways And Auxiliary Gutters

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2. Hoffman; a brand of Pentair Equipment Protection.
 - 3. MonoSystems, Inc.
 - 4. Square D.

- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 12 for indoor applications and Type 4X for all exterior and interior areas subject to moisture and corrosion unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 Surface Raceways

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated.
 - b. MonoSystems, Inc.
 - c. Wiremold / Legrand.
- C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated.
 - b. MonoSystems, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.

D. Tele-Power Poles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated.
 - b. MonoSystems, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.
2. Material: Aluminum with clear anodized finish.
3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.5 Boxes, Enclosures, And Cabinets

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. Hoffman.
6. Hubbell Incorporated.
7. Kraloy.
8. O-Z/Gedney.
9. RACO; Hubbell.
10. Robroy Industries.
11. Stahlin Non-Metallic Enclosures.
12. Thomas & Betts Corporation.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 - 1. Material: Cast metal.
 - 2. Type: Semi-adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Nonmetallic Floor Boxes: Nonadjustable, rectangular.
 - 1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Provide brass trim cover.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- L. Gangable boxes are prohibited.
- M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4X in all exterior non-hazardous locations and in interior wet and corrosive, but non-hazardous locations; Type 12 in interior locations with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Fiberglass.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets and Enclosures:

1. NEMA 250, Type as indicated on drawings. Where not specifically noted on the drawings, apply the following table:
 - a. NEMA 250; Type 1. Use only in atmospherically controlled clean areas such as offices.
 - b. NEMA 250; Type 12. Use in non-hazardous plant areas unless otherwise indicated. Use in equipment rooms.
 - c. NEMA 250; Type 4. Use for outdoor applications.
 - d. NEMA 250; Type 4X. Use for chemical handling and processing areas. Use where corrosive, non-hazardous atmospheres exist.
 - e. NEMA 250; Type 6P. Use for areas that may encounter temporary submergence.
 - f. NEMA 250; Type 7. Use for Class I hazardous locations.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 Handholes And Boxes For Exterior Underground Wiring

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Armorcast Products Company.
 - b. Oldcastle Precast, Inc.
 - c. Quazite: Hubbell Power Systems, Inc.
 - d. Synertech Moulded Products.
2. Standard: Comply with SCTE 77.
 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 6. Cover Legend: Molded lettering, legend as indicated.
 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 Source Quality Control For Underground Enclosures

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

Part 3 Execution

3.1 Raceway Application

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Underground Installations:
 - a. More than 5 Feet from Foundation Wall: Use thickwall nonmetallic conduit.
 - b. Within 5 Feet from Foundation Wall: Use rigid steel conduit.
 - c. In or Under Slab on Grade: Use rigid steel conduit elbows for risers and thickwall nonmetallic conduit for horizontal runs.
 - d. Minimum Size: 1 inch unless otherwise noted.
2. Outdoor Locations, Above Grade:
 - a. Non-Corrosive Environments: Use rigid steel conduit unless otherwise indicated.
 - b. Corrosive Environments (e.g. areas when waste water or chemicals may be present): Use PVC coated rigid galvanized steel conduit and fittings unless otherwise indicated.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC except in hazardous locations, listed and approved outdoor explosion-proof flexible conduit shall be used.
4. Minimum Size: 3/4 inch unless otherwise indicated.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. In Slabs Above Grade:
 - a. Use rigid steel conduit.
 - b. Maximum Size Conduit in Slab: 3/4 inch.
2. Wet and Damp Locations (no other corrosives): Use rigid galvanized steel conduit.
3. Dry Locations Not Treatment, Non-Chemical Areas:
 - a. Concealed: Use rigid steel conduit for feeders 2 inches and above: electrical metallic tubing for branch circuits and systems.

- b. Exposed: use rigid galvanized steel conduit.
 - 4. In Wet wells and Tanks and Processing Areas: Use PVC coated rigid galvanized steel conduit.
 - 5. In Pipe Gallery: use rigid galvanized steel conduit.
 - 6. In Chemical Rooms: Use thick wall Schedule 40 PVC conduit.
 - 7. In Contact with Concrete: Use rigid galvanized steel or PVC coated galvanized steel elbows and risers.
 - 8. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment: liquidtight flexible metal conduit except hazardous locations shall use listed explosion-proof flexible fittings.
- C. Minimum Raceway Size: 3/4-inch trade size except where otherwise indicated. Where connecting to equipment or instruments with hubs smaller than 3/4-inch, the LFMC final connection shall be reduced to match the equipment.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
- 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 Installation

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.
- B. Keep raceways at least 12 inches away from parallel runs of flues and steam or hot-water pipes and surfaces exceeding 104°F. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.

- D. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports and arrange to prevent misalignment.
- E. Support conduit using lay-in adjustable hangers, clevis hangers, and split hangers, material to match conduit.
- F. Group related conduits; support using conduit rack. Construct rack using channel and supports as specified under Section 26 05 29 "Hangers and Supports for Electrical Systems"; provide space on each for 50 percent additional conduits.
- G. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.
- H. Do not attach conduit to ceiling support wires.
- I. Arrange stub-ups so curved portions of bends are not visible above finished slab and protect from damage. Stub-ups shall be 6 inches above the floor unless equipment installation instructions limit to less.
- J. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches of enclosures to which attached.
- L. Raceways Embedded in Slabs:
 - 1. Run conduit parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete.
- M. Stub-ups to Above Recessed Ceilings:
 - 1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

- O. Install PVC coated conduit in accordance with manufacturer's instructions and as follows:
 - 1. All male threads on conduit, elbows and nipples shall be protected by application of a urethane coating.
 - 2. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
 - 3. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with PVC encapsulated nuts that cover the exposed portions of the threads.

- P. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

- Q. Arrange conduit to maintain headroom and present neat appearance. Where possible, install horizontal raceway runs above water and process piping. Maintain adequate clearance between conduit and piping.

- R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

- S. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

- T. Cut conduit square using saw or pipecutter; de-burr cut ends.

- U. Bring conduit to shoulder of fittings; fasten securely.

- V. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

- W. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration; use bonding bushings or wedges to ensure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.

- X. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts and dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
- Y. Use conduit hubs to fasten conduit to sheet metal boxes in plant, damp and wet locations to cast boxes.
- Z. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- AA. Install no more than equivalent of three 90 degree bends between boxes. Use conduit benders to make sharp changes in direction, as around beams. Use hydraulic one-shot bender to fabricate bends in metal conduit larger than 2 inch size. Low voltage and Signal System Raceways 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways 2-inch and smaller trade size in maximum lengths at 150 feet and with a maximum of two, 90 degree bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.
- BB. Avoid moisture traps; provide junction box with drain fitting at low points in conduit systems.
- CC. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- DD. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- EE. Provide seal-off fittings in raceways between areas of hazardous classification and unclassified areas.
- FF. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- GG. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service raceway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- HH. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- II. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- JJ. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for instruments, transformers and motors.
- KK. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

- LL. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- MM. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- NN. Locate boxes so that cover or plate will not span different building finishes.
- OO. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- PP. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- QQ. Set metal floor boxes level and flush with finished floor surface.
- RR. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 Sleeve And Sleeve-Seal Installation For Electrical Penetrations

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies as specified in Section 26 05 44.

3.4 Firestopping

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 26 05 44.

3.5 Protection

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.2 Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use designations indicated on Drawings for signage.

D. Delegated-Design Submittal: For arc-flash hazard study.

Part 2 Products

2.1 Performance Requirements

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 86 deg F, ambient; 180 deg F, material surfaces, \pm 100 deg F.

2.2 Color and Legend Requirements

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- B. Raceways and Cables Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- C. Warning labels and signs shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 Labels

- A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering comparable products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. Emedco.

- d. Grafoplast Wire Markers.
 - e. LEM Products Inc.
 - f. Marking Services, Inc.
 - g. Panduit Corp.
 - h. Seton Identification Products.
- B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Panduit Corp.
 - d. Seton Identification Products.
- C. Self-Adhesive Labels:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brother International Corporation.
 - c. Emedco.
 - d. Grafoplast Wire Markers.
 - e. Ideal Industries, Inc.
 - f. LEM Products Inc.
 - g. Marking Services, Inc.
 - h. Panduit Corp.
 - i. Seton Identification Products.

2. Preprinted, 3-mil- thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
 - a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.
3. Vinyl, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
 - a. Nominal Size: 3.5-by-5-inch.
4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 Bands and Tubes

- A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Panduit Corp.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Panduit Corp.

2.5 Tapes and Stencils

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Ideal Industries, Inc.
 - d. Marking Services, Inc.
 - e. Panduit Corp.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.
- C. Floor Marking Tape: 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
- D. Underground-Line Warning Tape
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.

- e. Reef Industries, Inc.
 - f. Seton Identification Products.
2. Tape:
- a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Color and Printing:
- a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
 - d. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - e. Width: 3 inches.
 - f. Overall Thickness: 5 mils.
 - g. Foil Core Thickness: 0.35 mil.
 - h. Weight: 28 lb/1000 sq. ft.
 - i. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

2.6 Tags

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.
 - e. Seton Identification Products.

2.7 Signs

- A. Baked-Enamel Signs:
 - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch grommets in corners for mounting.
 - 3. Nominal Size: 7 by 10 inches.
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Emedco.
 - d. Marking Services, Inc.
- B. Metal-Backed Butyrate Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.
 - 2. 1/4-inch grommets in corners for mounting.
 - 3. Nominal Size: 10 by 14 inches.

4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Emedco.
 - d. Marking Services, Inc.
- C. Laminated Acrylic or Melamine Plastic Signs:
 1. Engraved legend.
 2. Thickness:
 - a. For signs up to 20 sq. inches, minimum 1/16-inch.
 - b. For signs larger than 20 sq. inches, 1/8 inch thick.
 - c. Engraved legend as follows:
 - 1) Normal Systems – black letters on white face.
 - 2) UPS Systems – white letters on blue face.
 - 3) Emergency Systems – white letters on red face.
 - d. Self-adhesive.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
 3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.

2.8 Cable Ties

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ideal Industries, Inc.
 - 2. Marking Services, Inc.
 - 3. Panduit Corp.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.9 Miscellaneous Identification Products

- A. Paint: Comply with requirements in Painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless steel machine screws with nuts and flat and lock washers.

Part 3 Execution

3.1 Preparation

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 Installation

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- I. Painted Identification: Comply with requirements in Painting Sections for surface preparation and paint application.
- J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 Identification Schedule

- A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply stripes to the following finished surfaces:
 - 1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to raceways concealed within wall.
 - 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.
- D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "NORMAL POWER."
 - 3. "UPS."
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral: White.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral: Gray.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.
- I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes or self-adhesive vinyl labels with the conductor designation.

- J. Conductors to be Extended in the Future: Attach marker tape to conductors and list source.
- K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
 - 1. Install underground-line warning tape for direct-buried cables and cables in raceways.
- M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.
 - 1. Comply with NFPA 70E and ANSI Z535.4.
 - 2. Comply with Section 26 05 74 - Overcurrent Protective Device Arc-Flash Study requirements for arc-flash warning labels.

- P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer and load shedding.
- R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 2. Equipment to be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Switchgear.
 - d. Switchboards.
 - e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - f. Substations.

- g. Motor-control centers.
- h. Enclosed switches.
- i. Enclosed circuit breakers.
- j. Enclosed controllers.
- k. Variable-speed controllers.
- l. Push-button stations.
- m. Power-transfer equipment.
- n. Contactors.
- o. Remote-controlled switches, dimmer modules, and control devices.
- p. Battery-inverter units.
- q. Battery racks.
- r. Monitoring and control equipment.
- s. UPS equipment.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes: Distribution dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.2 Action Submittals

- A. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.3 Informational Submittals

- A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.
- B. Field quality-control reports.

1.4 Closeout Submittals

- A. Operation and maintenance data.

1.5 Delivery, Storage, and Handling

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

Part 2 Products

2.1 Manufacturers

- A. Subject to compliance with requirements, provide product indicated on the Drawings or comparable product by one of the following:
 - 1. Eaton Corporation: Electrical Sector; Cutler-Hammer Products.

2. General Electric Company.
3. Square D; a brand of Schneider Electric.

2.2 General Transformer Requirements

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Transformers Rated 15 kVA and Larger: Comply with DOE 2016 energy-efficiency levels as verified by certified prototype testing.
- D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- E. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 Distribution Transformers

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated.
 1. NEMA 250, Type 2 unless otherwise indicated. Core and coil shall be encapsulated within resin compound to seal out moisture and air.
- D. Transformer Enclosure Finish: Comply with NEMA 250.
 1. Finish Color: NSF/ANSI 49 gray.
- E. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.
- F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- H. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

- I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - 2. Indicate value of K-factor on transformer nameplate.
 - 3. Unit shall meet requirements of DOE 2016 with a K-factor equal to one.
- K. Wall Brackets: Manufacturer's standard brackets.
- L. Fungus Proofing: Permanent fungicidal treatment for coil and core.
- M. Low-Sound Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
 - 1. 9 kVA and less: 40 dB.
 - 2. 30 to 50 kVA: 45 dB.
 - 3. 51 to 150 kVA: 50 dB.
 - 4. 151 to 300 kVA: 55 dB.

2.4 Identification Devices

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 - Identification for Electrical Systems.

2.5 Source Quality Control

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
 - 1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
 - 2. Ratio tests at the rated voltage connections and at all tap connections.
 - 3. Phase relation and polarity tests at the rated voltage connections.
 - 4. No load losses, and excitation current and rated voltage at the rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:
 - a. High-voltage to ground.
 - b. Low-voltage to ground.
 - c. High-voltage to low-voltage.
9. Temperature tests.

Part 3 Execution

3.1 Examination

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

- C. Construct concrete bases according to Division 03 requirements for cast-in-place concrete and anchor floor-mounted transformers according to manufacturer's written instructions, and requirements in Section 26 05 29 - Hangers and Supports for Electrical Systems.
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 Connections

- A. Ground equipment according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 Field Quality Control

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports under Section 26 05 01 - Electrical Testing.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.
- D. Remove and replace units that do not pass tests or inspections and retest as specified above.
- E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 Adjusting

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 Cleaning

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.2 Definitions

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

1.3 Action Submittals

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.

5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.

1.4 Informational Submittals

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.5 Closeout Submittals

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 Maintenance Material Submittals

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers: Spares as scheduled.

1.7 Quality Assurance

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.8 Delivery, Storage, and Handling

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

- B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.9 Field Conditions

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner's Representative no fewer than 10 days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.
 - 3. Comply with NFPA 70E.

1.10 Warranty

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
 - 1. SPD Warranty Period: Five years from date of Substantial Completion.

Part 2 Products

2.1 Panelboards Common Requirements

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.
- D. Comply with NFPA 70.
- E. Enclosures: Surface-mounted, dead-front cabinets unless otherwise indicated.
 - 1. Rated for environmental conditions at installed location unless otherwise scheduled.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, NEMA 4X, stainless steel.
 - c. Chemical Areas: NEMA 250, Type 4X, stainless steel.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids (All Plant Locations not 4X): NEMA 250, Type 12.
 - 2. Height: 84 inches maximum.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 - 4. Finishes:
 - a. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat except stainless steel.
 - b. Back Boxes: Same finish as panels and trim.
 - c. Fungus Proofing: Where scheduled.

F. Incoming Mains:

1. Location: As scheduled; Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads where designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices scheduled as "SPACE".
- J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 Performance Requirements

- A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 Power Panelboards

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton.
 2. ABB.
 3. Square D; by Schneider Electric.
 4. Siemens.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or lugs only as scheduled.

- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 Lighting and Appliance Branch-Circuit Panelboards

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. Square D; by Schneider Electric.
 - 4. Siemens.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only as scheduled.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 Load Centers – Not Permitted

2.6 Disconnecting and Overcurrent Protective Devices

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. Square D; by Schneider Electric.
 - 4. Siemens.

- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Electronic Trip Circuit Breakers where scheduled:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
 - 4) Ground-fault pickup level, time delay, and I squared T response.
 3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 5. Subfeed Circuit Breakers: Vertically mounted.
 6. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.

- c. UL listed for reverse connection without restrictive line or load ratings.
- d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
- e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
- f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
- h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
- i. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
- j. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
- k. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- l. Multipole units enclosed in a single housing with a single handle.
- m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
- n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.7 Identification

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Computer-generated circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 Accessory Components and Features

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

Part 3 Execution

3.1 Examination

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.
- D. Equipment Mounting:
 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated, but no breaker shall be higher than 79 inches.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Mount surface-mounted panelboards to stainless steel slotted supports 3/4 inch in depth. Orient steel slotted supports vertically.
- J. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- L. Install filler plates in unused spaces.
- M. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- N. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 Identification

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 - Identification for Electrical Systems.
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.
- E. Install warning signs complying with requirements in Section 26 05 53 - Identification for Electrical Systems identifying source of remote circuit.

3.4 Field Quality Control

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 Adjusting

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 - Coordination Studies.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 - 1. Measure loads during period of normal facility operations.
 - 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 - 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 Protection

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Extra hard use specification-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. SPD receptacles, 125 V, 20 A.
4. Corrosion resistant receptacles, 125 V, 20 A.
5. Twist-locking receptacles.
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Toggle switches, 120/277 V, 20 A.
9. Wall plates.

1.2 Definitions

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

1.3 Action Submittals

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

- C. Samples: One for each type of device and wall plate specified, in each color specified.

1.4 Informational Submittals

- A. Field quality-control reports.

1.5 Closeout Submittals

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

Part 2 Products

2.1 General Wiring-Device Requirements

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.
- E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with requirements in this Section.
- F. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- G. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Corrosion Resistant Wiring Devices: Yellow.
 - 3. SPD Devices: Blue.

4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.
- H. Wall Plate Color: For plastic covers, match device color.
- I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 Extra Hard Use Specification-Grade Receptacles, 125 V, 20 A

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton (Arrow Hart).
 2. Hubbell Incorporated; Wiring Device-Kellems.
 3. Leviton Manufacturing Co., Inc.
 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Duplex Receptacles, 125 V, 20 A:
 1. Description: Two pole, three wire, and self-grounding.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498 and FS W-C-596.
- C. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 1. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498 and FS W-C-596.
- D. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:
 1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498 and FS W-C-596.

4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
- E. Corrosion-Resistant Duplex Receptacle, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498.
 4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI Receptacles, 125 V, 20 A

- A. Duplex GFCI Receptacles, 125 V, 20 A:
1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Type: Non-feed through.
 4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 SPD Receptacles, 125 V, 20 A

- A. Duplex SPD Receptacles, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. LED indicator light.
 2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
 3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
 4. Configuration: NEMA WD 6, Configuration 5-20R.
 5. Standards: Comply with NEMA WD 1, UL 498, UL 1449, and FS W-C-596.

2.5 Twist-Locking Receptacles

- A. Twist-Lock, Single Receptacles, configurations as noted:

1. Configuration: NEMA WD 6, Configuration as indicated.
2. Standards: Comply with UL 498.
3. Provide corrosion resistant device where indicated.

2.6 Pendant Cord-Connector Devices

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.
- B. Configuration: NEMA WD 6, Configurations as indicated.
- C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
- E. Standards: Comply with FS W-C-596.

2.7 Cord and Plug Sets

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SO jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 Toggle Switches, 120/277 V, 20 A

- A. Antimicrobial, Single-Pole Switches, 120/277 V, 20 A:
 1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
 2. Standards: Comply with UL 20 and FS W-S-896.
- B. Two-Pole Switches, 120/277 V, 20 A.

- C. Antimicrobial, Double-Pole Switches, 120/277 V, 20 A:
 - 1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
 - 2. Standards: Comply with UL 20 and FS W-S-896.
- D. Antimicrobial, Three-Way Switches, 120/277 V, 20 A:
 - 1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
 - 2. Standards: Comply with UL 20 and FS W-S-896.
- E. Lighted Single-Pole Switches, 120/277 V, 20 A:
 - 1. Description: Handle illuminated when switch is off.
 - 2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.
- F. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:
 - 1. Description: Factory-supplied key in lieu of switch handle.
 - 2. Standards: Comply with UL 20 and FS W-S-896.
- G. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A:
 - 1. Description: For use with mechanically held lighting contactors.
 - 2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.9 Wall Plates

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.035-inch- thick, satin-finished, Type 302 stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

Part 3 Execution

3.1 Installation

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 GFCI Receptacles

- A.** Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 Identification

- A.** Comply with Section 26 05 53 - Identification for Electrical Systems.

- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 Field Quality Control

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Perform the following tests and inspections:
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Wiring device will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Motor-control centers.
 - c. Panelboards.
 - d. Switchboards.
 - e. Enclosed controllers.
 - f. Enclosed switches.
2. Spare-fuse cabinets (where indicated).

1.2 Action Submittals

- #### A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 3. Current-limitation curves for fuses with current-limiting characteristics.
 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.

5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.3 Maintenance Material Submittals

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.4 Field Conditions

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

Part 2 Products

2.1 Manufacturers

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Bussmann.
 2. Edison; a brand of Cooper Bussmann.
 3. Littelfuse, Inc.
 4. Goulds.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 Cartridge Fuses

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 1. Type RK-1: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 2. Type RK-5: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.

4. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - C. Comply with NEMA FU 1 for cartridge fuses.
 - D. Comply with NFPA 70.
 - E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 Spare-Fuse Cabinet

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 1. Size: 24"H x 20"W x 6"D minimum.
 2. Finish: Gray, baked enamel.
 3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

Part 3 Execution

3.1 Examination

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Fuse Applications

A. Cartridge Fuses:

1. Service Entrance: Class L, time delay and Class RK1, time delay based upon size.
2. Feeders: Class L, time delay and Class RK1, time delay based upon size.
3. Motor Branch Circuits: Class RK5, time delay.
4. Power Electronics Circuits: Class J, high speed.
5. Control Transformer Circuits: Class CC, time delay, control transformer duty.
6. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 Installation

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner's Representative.

3.4 Identification

- A. Install labels complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

Part 1 General

1.1 Summary

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Receptacle switches.
 - 4. Molded-case circuit breakers (MCCBs).
 - 5. Enclosures.

1.2 Definitions

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.3 Action Submittals

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.4 Informational Submittals

- A. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 Closeout Submittals

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 Quality Assurance

- A. Testing Agency Qualifications: Refer to Division 26 Section "Electrical Testing."
- B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NFPA 70.

1.7 Project Conditions

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.

1.8 Coordination

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

Part 2 Products

2.1 Fusible Switches

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. Square D; by Schneider Electric.
 - 4. Siemens.
- B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Double Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
 - 1. Equipment Ground Kit (ALL Units): Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit (Where Indicated): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit (ALL Motor Circuits): Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle (All): Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches (Where Noted): Labeled for use as service equipment.
8. Visible break polycarbonate view window (ALL).

2.2 Nonfusible Switches

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Eaton.
 2. ABB.
 3. Square D; by Schneider Electric.
 4. Siemens.
- B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Double Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
 1. Equipment Ground Kit (ALL Units): Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit (Where Indicated): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Auxiliary Contact Kit (ALL Motor Circuits): Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 4. Hookstick Handle (All): Allows use of a hookstick to operate the handle.

5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches (Where Noted): Labeled for use as service equipment.
7. Visible break polycarbonate view window (ALL).

2.3 Receptacle Switches

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Eaton
 2. ABB
 3. Square D; a brand of Schneider Electric.
 4. Crouse-Hinds.
 5. Appleton Electric.
- B. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 60 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.4 Molded-Case Circuit Breakers

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Eaton.
 2. ABB.
 3. Square D; by Schneider Electric.
 4. Siemens.

- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents. 10kA minimum for 240 VAC and lower systems and 65kA minimum for 480V systems unless otherwise indicated.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A and larger.
- D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 - 1. Instantaneous trip and I²t response.
 - 2. Long- and short-time pickup levels.
 - 3. Long- and short-time time adjustments.
 - 4. Ground-fault pickup level, time delay, and I²t response.
- E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- G. Features and Accessories where indicated:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.5 Enclosures

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 12.
 - 2. Outdoor Locations: NEMA 250, Type 4X.
 - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 - 5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

Part 3 Execution

3.1 Examination

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 Identification

- A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 Field Quality Control

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- D. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 Adjusting

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 - Overcurrent Protective Device Coordination Study.

END OF SECTION

Surge Protection for Low-Voltage Electrical Power Circuits

Part 1 General

1.1 Summary

- A. Section includes SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
 - 1. Section 26 24 16 - Panelboards for factory-installed SPDs.

1.2 Definitions

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.3 Action Submittals

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.4 Informational Submittals

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.5 Closeout Submittals

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 Warranty

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

Part 2 Products

2.1 General SPD Requirements

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be the nominal system voltage.

2.2 Panel Suppressors

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advanced Protection Technologies Inc. (APT).
 - 2. Eaton Corporation.
 - 3. Emerson Electric Co.
 - 4. GE Zenith Controls.
 - 5. Schneider Electric Industries SAS.
- B. SPDs: Comply with UL 1449, Type 2.
 - 1. Include LED indicator lights for power and protection status.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.

- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 120 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. Comply with UL 1283.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 120/240 V three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 1200 V for 120/240 V.
 - 2. Line to Ground: 1200 V for 120/240 V.
 - 3. Neutral to Ground: 1200 V for 120/240 V.
 - 4. Line to Line: 2000 V for 120/240 V

2.3 Enclosures

- A. Indoor Enclosures: NEMA 250, Type to match Panelboard.

2.4 Conductors and Cables

- A. Power Wiring: Same size as SPD leads, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

Part 3 Execution

3.1 Installation

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
2. Controls: Comply with wiring methods in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

3.2 Field Quality Control

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 2. Inspect anchorage, alignment, grounding, and clearances.
 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 Startup Service

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 Demonstration

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

Couplings, Adapters, and Specials for Process Piping

Part 1 General

1.1 Section Includes

- A. Ductile Iron Couplings
- B. Fabricated Steel Couplings
- C. Flange Adapter Couplings
- D. Dismantling Joints

1.2 Related Sections

- A. Section 40 05 51 – Common Requirements for Process Valves
- B. Section 40 05 97 –Identification for Process Equipment

1.3 Submittals

- A. Submit under provisions of Section 01 33 00.
- B. Product Data: Provide data on materials, operational components, and accessories. Submit manufacturer's descriptive and technical literature for each component, including design recommendations; pressure and temperature ratings; dimensions; and chemical resistance to each chemical and chemical mixture in the liquid stream.
- C. Operations and Maintenance Data: Submit under provisions of Section 01 78 23. Provide manuals for all operational devices.

Part 2 Products

2.1 Materials and Equipment

- A. Piping specialties, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.
- B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.
- C. Pipe fittings shall be compatible with the applicable pipe materials.

D. Standard Products

1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.
- E. All materials in contact with potable water shall be certified to NSF Standard 61 and shall comply with Federal lead-free requirements.

2.2 Ductile Iron Couplings (DI CPLG)

- A. Ductile iron couplings for use in connecting of smooth end joints of cast iron, ductile iron, asbestos cement, steel, PVC or other types of pipe must be capable of fitting this variety of pipes with one set of follower flanges or end rings.
- B. Sleeve shall be of Ductile Iron ASTM A536. Ends shall have a smooth inside taper to provide uniform gasket seal. Sleeve shall be given a shop coat of oil-modified urethanes, corrosion-resistant paint, or epoxy coating.
- C. Follower flanges or end rings shall be of the thickness determined by the coupling size, and shall be ductile iron, ASTM-536. Flanges shall be identified by a color-coded shop coat finish.
- D. Gaskets shall be compression – type, formed with Virgin Styrene Butadiene Rubber (SBR,) ASTM D2000 3 BA715, and compounded with ingredients to produce permanence and resistance to set after installation. O.D. range shall be imprinted/molded on the gasket in permanent ink (Minimum.)
- E. Bolts and Nuts shall be of high-strength, low-alloy steel, with nominal coarse thread, and hex nuts with black finish.
- F. Dimensions and minimum stress values shall be in accordance with AWWA/ANSI C111/A21.11.
- G. Manufacturers and Products:
1. Smith-Blair, Inc. 441
 2. JCM Industries 210
 3. Romac Industries, Inc. 501
 4. Or Approved Equal.

2.3 Fabricated Steel Couplings (FAB CPLG)

A. Sleeve-Type Couplings, 1 inch through 48 inches

1. Sleeve-type couplings shall be used for joining plain end pipe sections in a flexible manner with a diameter to properly fit the pipe. Coupling shall be suitable for pipe size and material, with stiffeners provided for HDPE pipe. Couplings shall comply with AWWA C219. Materials shall be as follows:
 - a. Sleeve: ASTM A53, ASTM A513 or Carbon Steel having minimum yield of 30,000 PSI.
 - b. Followers: Ductile Iron ASTM A536, Steel AISI C 1020, or A715 Grade 80 HSLA Steel. Design for a high strength-to-weight ratio. Follower thickness determined by coupling size.
 - c. Bolts & Nuts: Stainless steel.
 - d. Gasket: Nitrile (Buna N) NSF 61 compounded to produce superior storage and performance characteristics while resisting water, acids, alkalies, most (aliphatic) hydrocarbon fluids, and other chemicals for a temperature range of -20°F to 180°F.
 - e. Finish: Fusion Bonded Epoxy Finish
2. Working Pressure: Up to 150 PSI
3. Manufacturers/Models
 - a. Smith-Blair, Inc. 411
 - b. JCM Industries 201
 - c. Romac Industries, Inc. 400
 - d. Or Approved Equal.

B. Transition Couplings:

1. Transitional couplings may be used to connect two pipes that have small differences in outside diameter. A fully assembled transitional coupling shall be sized to properly fit pipe diameters. Couplings shall comply with AWWA C219. Materials shall be as follows:
 - a. Sleeve: ASTM A53, ASTM A513 or Carbon Steel having minimum yield of 30,000 PSI.
 - b. Followers: Ductile Iron ASTM A536, or Steel AISI C 1020. Design for a high strength-to-weight ratio. Follower thickness determined by coupling size.

- c. Bolts & Nuts: Stainless steel with heavy semi-finished hexagon nuts.
 - d. Gasket: Nitrile (Buna N) NSF 61 compounded to produce superior storage and performance characteristics while resisting water, acids, alkalies, most (aliphatic) hydrocarbon fluids, and other chemicals for a temperature range of -20°F to 180°F.
 - e. Finish: Fusion Bonded Epoxy Finish
2. Working Pressure: Up to 150 PSI
 3. Manufacturers/Models
 - a. Smith-Blair, Inc. 413.
 - b. JCM Industries 203
 - c. Or Approved Equal.

2.4 Flange Coupling Adapters (FCA)

- A. Flange coupling adapters shall be of the size and pressure rating required for each installation and shall be suitable for use on the pipe to be connected.
- B. All couplings shall have a sufficient number of factory installed anchor devices to meet or exceed the test pressure rating for this project, or 300 psi minimum.
- C. Sleeve shall be of A36, A283 Gr. C, or Carbon Steel having a minimum yield of 30,000 PSI. Ends shall have a smooth inside taper to provide uniform gasket seal. Sleeve shall be given a shop coat of oil-modified urethanes, corrosion-resistant paint, or epoxy coating.
- D. Flanges shall be flat face flanges complying with AWWA C207 Class D, ANSI 150 lb. drilling.
- E. Gland shall be 65-45-12 Ductile Iron (ASTM A536) and shall be coated with the same material as the sleeve. MJ gaskets shall be standard SBR gaskets complying with AWWA C111 and ANSI A21. 11.
- F. Bolts and Nuts shall be of high-strength, low-alloy steel, per AWWA C111.
- G. Dimensions and minimum stress values shall be in accordance with AWWA/ANSI C111/A21.11.
- H. Manufacturers and Products:
 1. Smith Blair, Style 911
 2. Romac Industries, Inc. RFCA
 3. Approved Equal

2.5 Dismantling Joints (Restrained) (D JT)

- A. Restrained dismantling joint fittings shall meet the specifications set forth in AWWA C219, be of the size and pressure rating required for each installation, and shall be suitable for use on the pipe to be connected. Restrained dismantling joint fittings shall have a sufficient number of factory installed bolts and tie rods to meet or exceed the test pressure rating for this project, or 150 psi minimum.
- B. Followers for 3" thru 12" shall be Ductile Iron 65-45-12 per ASTM A536; for size 14" and larger shall be Carbon Steel C1020 per ASTM A576. Sleeve and spool weldment material shall be Carbon Steel per ASTM A283C. Flanges shall meet AWWA C207 Class D Steel Ring Flange, compatible with ANSI Class 125 and 150 bolt circles. Total angular deflection up to 1-1/2° per joint. Bolts, nuts and tie rods shall be Type 304 stainless steel. Fittings shall have a fusion bonded epoxy finish which meets application methods AWWA C213.
- C. Gaskets shall be Nitrile (Buna-N) per ASTM D2000, NSF/ANSI 61 and 372 certified and compounded to resist water, oil, natural gas, acids, alkalis, most (aliphatic) hydrocarbon fluids, and many other chemicals. Temperature range: -20°F to +180°F.
- D. Manufacturers and Products:
 - 1. Smith Blair, Model 975
 - 2. Romac Industries, Style DJ400
 - 3. Or Approved Equal

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.
- B. System Preparation
 - 1. Provide accessibility to piping specialties for control and maintenance.

3.3 Manufacturer's Field Services

- A. Obtain manufacturer's technical assistance for Contractor training, installation inspection, start up, and owner operating and maintenance training.

Couplings, Adapters, and Specials for Process Piping

- B. Follow manufacturer's instructions for installation.
- C. **Metallic Piping Couplings:** Thrust ties shall be provided where shown on the contract drawings and where required to restrain the force developed by 1.5 times the maximum allowable operating pressures specified. For metallic pipe other than ductile iron, thrust ties shall be attached with fabricated lugs. For ductile iron pipe, thrust ties shall be attached with socket clamps against a grooved joint coupling or flange. For exposed installations, zinc-plated nuts and bolts shall be used. However, high-strength, low-alloy steel, in accordance with AWWA C111/A21.11, may be substituted for use on cast iron and ductile iron couplings. For buried and submerged installations, TP304 stainless steel bolts and nuts shall be provided. Steel middle rings and followers shall be fusion bonded epoxy-lined and coated in accordance with Section 09 90 15 - Paint and pressure tested beyond yield point.
- D. **Sleeve-Type Couplings:** Sleeve-type couplings shall be used for joining plain end pipe sections in a flexible manner with a diameter to properly fit the pipe.
- E. **Transition Couplings:** Transitional couplings may be used to connect two pipes of the same material that have small differences in outside diameter. A fully assembled transitional coupling shall be sized to properly fit pipe diameters.

END OF SECTION

Part 1 General

1.1 Work Included

- A. Furnish and install the following:
 - 1. Pipe Supports
 - 2. Anchor Bolts
 - 3. Cable Trays

1.2 Submittals

- A. Submit in accordance with Section 01 33 00.
- B. Product Data:
 - 1. Provide product data for each type of pipe support required.
 - 2. Submit manufacturer's data on cable tray including, but not limited to, types, materials, finishes, rung spacing, inside depths and fitting radii. For side rails and rungs, submit cross sectional properties including Section Modulus (Sx) and Moment of Inertia (Ix).
- C. Shop Drawings:
 - 1. Indicate locations and mounting heights of each type of hardware.
 - 2. Submit manufacturer's templates and installation instructions.
 - 3. Submit drawings of cable tray and accessories including clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, and fittings, showing accurately scaled components.

1.3 Quality Assurance

- A. Existing piping support systems shall be replaced in kind with new material. New support system shall be equal to or exceed the existing support system. .
- B. Steel pipe supports shall have the manufacturer's name, part number, and applicable size stamped in the part itself for identification.
- C. All materials used in manufacturing supports shall be capable of meeting the respective ASTM standard specifications with regard to tests of physical and chemical properties and be in accordance with MSS SP-58.

1.4 Design Requirements

A. General:

1. Supports shall be of manufacturer's standard design and shall be adequate to maintain the supported load in proper position under all operating conditions. Meet requirements of MSS SP58 and ASME B31.1 or as modified by this Section.
2. Additional temporary or permanent pipe supports may be required to facilitate construction.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes and internal pressures, including insulation and weight of fluid in pipes.
2. Maximum support spacing and minimum rod size: In accordance with MSS SP58, Table 3 and 4, excerpts of which follow below:

| Nominal Pipe Size (inches) | Maximum Spacing (feet) |
|----------------------------|------------------------|
| ½ to 1-1/4 | 5 |
| 1-1/2 | 7.5 |
| 2 | 10 |
| 3-4 | 12 |
| 6-8 | 15 |
| Over 8 | 20 |

- a. Ductile or Cast Iron pipe 8 inches and smaller: Maximum span limited to that for standard weight steel pipe for water service with a minimum of one support per pipe section at the joints.
 - b. Ductile or Cast Iron pipe 10 inches and larger: Maximum span limited to 20 feet with a minimum of one support per pipe section at the joints.
- 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. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, the Contractor shall submit a certification stating that such requirements have been complied with.

1.5 Coordination

- A. Coordinate work under provisions of Section 01 33 00 and Section 01 61 00.
- B. Coordinate work with installation of process piping, piping insulation, and valves.

1.6 Delivery, Storage, and Handling

- A. Deliver, store, protect, and handle products to site under provisions of Section 01 66 00.
- B. Deliver items in their original factory shipping cartons.

Part 2 Products

2.1 General

- A. Verify that field measurements are as instructed by the manufacturer.
- B. Manufacturer: Unless otherwise specified herein, pipe supports shall be as manufactured by Cooper B-Line, Inc. or engineer approved equal. Any reference to a specific figure number or a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary. Any item equal in type, style, quality, design and performance will be considered for approval.

2.2 Elbow and Flange Supports

- A. Elbow with Adjustable Stanchion:
 - 1. Anvil Figure 62C Base for sizes 2 inches through 18 inches.
- B. Elbow with Non-adjustable Stanchion:
 - 1. Anvil Figure 63A or 63B Base for sizes 2-1/2 inches through 42 inches.
- C. Flange Support with Adjustable Base:
 - 1. Standard Model S89, for sizes 2 inches through 24 inches.

2.3 Intermediate Pipe Guides

- A. Hold Down Pipe Guide:
 - 1. Cooper B-Line Figure B3552 for sizes 1-1/2 inches through 30 inches.
- B. U-Bolts, with double nuts to provide nominal 1/8 inch to 1/4 inch clearance around pipe; MSS SP58, Type 24
 - 1. Cooper B-Line Figure B3188 and B3188NS
 - 2. Anvil Figure 137 and 137S.

2.4 Pipe Anchors

- A. Anchor Chair with U-bolt Strap shall be Cooper B-Line Figure B3147A or Figure B3147B.

2.5 Accessories

- A. Anchor Bolts:
 - 1. Size and Material: Sized by Contractor for required loads, ½ inch minimum diameter, and as specified in Division 5.
 - 2. Bolt Length (Extension above top of nut):
 - a. Minimum length: Flush with top of nut.
 - b. Maximum length: No more than a full nut depth above the top of nut.

2.6 Finishes

- A. Indoor Finishes
 - 1. Hangers shall be zinc plated in accordance with ASTM B633.
 - 2. Strut channels shall be pre-galvanized in accordance with ASTM A653 SS Grade 33 G90.

Part 3 Execution

3.1 Inspection

- A. Verify that surfaces are ready to receive work and dimensions are as instructed by the manufacturer and required to provide proper support.
- B. Beginning of installation means acceptance of existing conditions.

3.2 Installation

- A. General
 - 1. All pipes, horizontal and vertical, shall be adequately supported from the building structure by pipe hanger and supports specified in Part 2 - Products. Install support systems in accordance with MSS SP58, unless shown otherwise.
 - 2. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings, and to minimize all pipe forces at pump housings. Pump housings shall not be utilized to support connecting pipes.

3. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
 4. Support no pipe from pipe above it or from metal stairs, ladders, or walkways unless it is so indicated on the Contract Drawings or specifically directed by the Engineer.
 5. Supports shall be provided at changes in direction and elsewhere as shown on the Contract Drawings or specified herein.
 6. Do not use adhesive anchors for attachment of supports to ceilings or walls.
 7. Do not install pipe hangers or supports in equipment access areas or bridge crane runs.
 8. Install hangers to provide a minimum of 1/2 inch space between finished covering and adjacent work.
 9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement during startup and shutdown.
 10. Install lateral supports for lateral 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.
- C. 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 diameters and 14 pipe diameters from each joint or loop.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. Wall Pipes
- B. Floor Pipes
- C. Pipe Sleeves

1.2 Related Sections

- A. Section 40 23 00 – Water and Wastewater Process Piping

1.3 Submittals

- A. Submit under provisions of Section 01 33 00.
- B. Product Data: Provide data on materials, operational components, and accessories. Submit manufacturer's descriptive and technical literature for each component, including design recommendations; pressure and temperature ratings; dimensions; and chemical resistance.
- C. Operations and Maintenance Data: Submit under provisions of Section 01 78 23.

Part 2 Products

2.1 Materials and Equipment

- A. Piping specialties, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.
- B. Components that serve the same function and are the same size shall be identical products of the same manufacturer
- C. Pipe fittings shall be compatible with the applicable pipe materials.
- D. Standard Products
 - 1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.
- E. All materials in contact with potable water shall be certified to NSF Standard 61 and shall comply with Federal lead-free requirements.

2.2 Wall Pipes and Floor Pipes

- A. Wall pipes and floor pipes shall be manufactured of ductile iron, grade 60-42-10, (minimum tensile strength: 60,000 psi; minimum yield strength: 42,000 psi; minimum elongation: 10%) in accordance with AWWA C151.
- B. Ends shall be as shown on the drawings. Where required, flanges and MJ bells can be tapped for studs.
- C. Wall pipe shall be fabricated of Special Class 53 thickness ductile iron pipe, unless otherwise noted.
- D. Wall pipe shall be furnished with one fabricated thrust/water stop collar design with 360° fillet welds on both sides of the collar.
- E. Unless otherwise noted, all cast-on flanges shall comply with AWWA C110 or C153, and all threaded-on flanges shall comply with AWWA C115.
- F. All mechanical joints shall comply with AWWA C111. Threaded-on or otherwise fabricated MJ bells shall be per applicable portions of AWWA C115 and C153.
- G. All wall pipes and floor pipes shall be provided with manufacturer's standard asphaltic coating.

2.3 Wall Sleeves

- A. Stainless Steel Sleeves
 - 1. Provide stainless steel sleeves for all pipes passing through concrete or masonry structures, or as shown on the Drawings. The sleeves shall be provided free of welding slag. Stainless steel sleeve shall be fabricated of 304 stainless steel. Stainless steel sleeve sizes through 10" shall be Schedule 40S pipe or standard wall thickness. Stainless steel sleeve sizes 12" and larger shall have a .375" or standard wall thickness. Sleeves through wall shall be cast in place and the pipe shall be installed centered in sleeve. Provide minimum 2" x 1/4" thick collar/water-stop of the same type of steel as the sleeve. The collar shall be welded all around on both sides to the sleeve at the point on the sleeve that positions it at the mid-point of the structural wall when the sleeve is in place.
- B. HDPE Sleeves
 - 1. Where pipes must pass through walls and floors of new structures, unless otherwise shown or specified, install molded non-metallic high density polyethylene sleeves. Sleeves shall have integrally formed hollow water stop sized having a minimum of four inches larger than the outside diameter of the sleeve itself and allowing 1/2" movement between wall forms to resist pour forces. Each sleeve assembly shall have end caps manufactured of the same material as the sleeve itself and installed at each end of the sleeve so as to prevent deformation during the initial concrete pour, and to facilitate attaching the sleeve to the wall forms. End caps will remain in place to protect the opening from residual debris and rodent entry prior to pipe insertion.

2. Sleeves shall be Garlock Pipeline Technologies Model CS CENTURY-LINE sleeves, or equal.
- C. Hydrostatic Seals
1. Potable Water Contact: Modular seals shall be Model "S61" LINK-SEAL® Modular Seal NSF 61 Certified for use in potable water, or equal. Bolts and nuts shall be 316 stainless steel. Seal element shall be made from Black NSF 61 certified EPDM materials, with Blue reinforced Nylon Polymer Pressure plates. Each shipment shall be packaged with a defining "NSF 61" label and batch number for traceability.
- D. Galvanizing: Galvanizing shall be hot-dip applied and meet the requirements of ASTM A153/A153M. Stainless steel components may be substituted where galvanizing is specified.

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.
- B. System Preparation
1. Provide accessibility to piping specialties for control and maintenance.

END OF SECTION

Ductile Iron Process Piping

| Item | Description |
|----------|---|
| General | <ul style="list-style-type: none"> A. Pipe fittings shall be compatible with the applicable pipe materials. B. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. C. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372. D. Pipe supplier shall submit certification that source manufacturing facility has been producing ductile iron pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. E. Testing of pipe required by AWWA A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. F. Pipe shall be handled during manufacture and shipped without nesting (i.e., insertion of one pipe inside another) |
| Pipe | <ul style="list-style-type: none"> A. Exposed/Aboveground <ul style="list-style-type: none"> 1. Grooved: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure. 2. Flanged: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure. |
| | <ul style="list-style-type: none"> A. Cement Mortar: Double cement lining conforming to AWWA C104/A21.4. |
| Coatings | <ul style="list-style-type: none"> A. Above ground or exposed ductile iron piping shall be factory primed with a paint system compatible with the paint systems specified in Section 09 90 15. |
| Fittings | <ul style="list-style-type: none"> A. Lined and coated same as pipe. B. Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psig minimum working pressure. Follower glands shall be ductile iron. C. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure, Victaulic or equal. D. Flanged: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed. |
| Joints | <ul style="list-style-type: none"> A. Mechanical: 250 psig minimum working pressure. B. Flanged: Class 125 flat face. Ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. E. Branch Connections: Connections 3 inches and |

Ductile Iron Process Piping

| | |
|-----------------|---|
| | smaller shall be made with service saddles as specified in Section 40 05 06. |
| Couplings | <p>A. Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536, Victaulic or equal.</p> <p>B. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536, Victaulic or equal.</p> |
| Bolting | <p>A. Mechanical and Grooved End Joints: Manufacturer's standard.</p> <p>B. Flanged: Bolts and accessories shall be carbon steel conforming to the requirements of ASTM A307, Grade B.</p> |
| Gaskets | <p>A. General: Gaskets in contact with potable water shall be NSF 61 certified.</p> <p>B. Mechanical Joints - Rubber conforming to AWWA C111/A21.11.</p> <p>C. Grooved End Joints: EPDM conforming to ASTM D2000 and AWWA C606.</p> <p>E. Flanged – Liquid Service: Gaskets shall be 1/8 inch thick, vulcanized synthetic rubber, reclaimed rubber is not acceptable.</p> |
| Joint Lubricant | Manufacturer's Standard |

END OF SECTION

Stainless Steel Process Piping

| Item | Size | Description |
|--------------------|--------------------|--|
| General | | <p>A. Pipe fittings shall be compatible with the applicable pipe materials.</p> <p>B. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation.</p> <p>C. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372.</p> <p>D. Pipe supplier shall submit certification that source manufacturing facility has been producing steel pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years.</p> <p>E. Pipe shall be handled during manufacture and shipped without nesting (i.e., insertion of one pipe inside another)</p> |
| Pipe | 2" and smaller | ASTM A312/A312M, seamless, Grade TP304, pickled and passivated, Schedule 40S with dimensions conforming to ASME B36.19. |
| | 2-1/2" and larger | Manufactured from ASTM-A240 annealed and pickled sheets and plates in accordance with ASTM A778, Grade TP304L, with dimensions conforming to ASME B36.19. |
| | 2-1/2" to 6" | Schedule 10S |
| Fittings | 1-1/2" and smaller | Threaded Fittings: Forged, 1000 psi CWP, austenitic stainless steel, ASTM A182/A182M Grade TP304, conforming to ASME B16.11, and threaded in accordance with ASME B1.20.1. |
| | 2" and 2-1/2" | Welding Fittings: Butt-weld type, ASTM A403/A403M, material matching piping; annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long-radius elbows unless shown otherwise. |
| | 3" and larger | Welding Fittings: Welding fittings shall be butt-weld type, material matching piping, ASTM A774/A774M, pickled and passivated; fitting wall thickness to match adjoining pipe; long-radius elbows unless shown otherwise. |
| Joints | 2" and smaller | Threaded or flanged at valves and equipment, as required or shown. |
| | 2-1/2" and larger | Butt-welded or flanged at valves and equipment. |
| Branch Connections | 1-1/2" and smaller | Threaded straight or reducing tees in conformance with fittings specified above. For welded or grooved pipe, use threadolet. |
| | 2" and larger | Butt-welding tee in conformance with fittings specified above. |

Stainless Steel Process Piping

| | | |
|------------------|----------------|---|
| Flanges | All | <p>Forged stainless steel, ASTM A182/A182M, Grade F304L, ASME B16.5, slip-on or welding neck, faced and drilled to ASME B16.5 Class 150 with a 1/16 inch raised face. Weld-on slip-on flanges inside and out.</p> <p>Blind flanges, exposed to atmosphere and not immersed in liquid or buried shall be stainless steel.</p> |
| Unions | 2" and smaller | Threaded forged: ASTM A182/A182M, Grade F316, 2000 or 3000 pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe. |
| Bolting | All | <p>Forged flanges and flanged joints in sumps, wet wells, submerged and wetted installations: ASTM A320, Grade B8M, Class 1 hex head bolts, ASTM A194/A194M Grade 8H hex nuts, and ASTM F436 washers at nuts and bolt heads. Achieve 40 to 60 percent of bolt minimum yield stress. Use anti-seize coatings in assembly of nuts and bolts.</p> <p>Van Stone Flanges and anywhere mating flange on equipment is cast iron and gasket is flat ring: Carbon steel A307 Grade B hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 to 60 percent of bolt minimum yield stress.</p> |
| Gaskets | All flanges | <p>General: Gaskets in contact with potable water shall be NSF 61 certified.</p> <p>1/8 inch thick EPDM, hardness No.60 (Shore A), rated 250 degrees continuous and conforming to ASME B16.21, and ASTM D1330, Steam Grade.</p> |
| Thread Lubricant | | Nickel-pigmented Polytetrafluoroethylene (PTFE) pipe-thread tape designed for stainless steel pipe. |

END OF SECTION

Part 1 General

1.1 Related Sections

- A. Section 09 90 15 - Paints
- B. Section 40 05 57 - Actuators for Process Valves and Gates.
- C. Section 40 05 62 - Plug Valves.
- D. Section 40 05 63 - Ball Valves.
- E. Section 40 05 64 - Butterfly Valves.

1.2 System Description

- A. This specification covers the requirements for above and below grade liquid process valves and accessories located both inside and outside of treatment plants.
- B. Performance Requirements
 - 1. Flanges, valves, fittings, and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

1.3 Submittals

- A. Submit in accordance with Section 01 33 00.
- B. Shop Drawings:
 - 1. Product data sheets for each make and model of valve. Indicate valve Type number, applicable Tag number, and facility name/number or service where used.
 - 2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - 3. Sizing calculations for open-close/throttle and modulating valves.
- C. Manufacturer's Certificate: Submit Manufacturer's Certificate of Compliance for:
 - 1. Valves used in Potable Water: Compliance with NSF 61 and Federal lead-free requirements.
 - 2. Butterfly valves: full compliance with AWWA C504.

- D. Operations and Maintenance Data: As specified in Section 01 78 23.
 - 1. Submit 6 copies each of operation and maintenance manuals in indexed booklet form. Detail in the Operation Manuals the step-by-step procedures required for specialized startup, operation, and shutdown of piping systems, and include the manufacturer's name, model number, parts list and brief description of piping equipment such as valves and other appurtenances and their basic operating features.
 - 2. List in the Maintenance Manuals routine maintenance procedures and troubleshooting guides for the equipment and include piping layout and valve locations.

1.4 Delivery, Storage, and Handling

- A. Materials delivered and placed in storage shall be stored with protection from the weather, excessive humidity variation, excessive temperature variation, dirt, dust and/or other contaminants.
- B. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged shall be replaced at the Contractor's expense. During installation, piping shall be capped to keep out dirt and other foreign matter.
- C. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage. Valves shall be handled and stored in accordance with the manufacturer's recommendation.

1.5 Maintenance

- A. Service: Services for automatic valve systems shall be provided by a manufacturer's representative who is experienced in the installation, adjustment and operation of the equipment specified. The representative shall inspect the installation and supervise the adjustment and testing of the equipment.
- B. Extra Materials
 - 1. Submit the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation. Concurrent with delivery and installation, spare parts for each different item of material and equipment specified that is recommended by the manufacturer to be replaced any time up to 1 year of service shall be furnished. Extra materials shall include 2 of the following spare parts for each type and size of valve: gaskets, all elastomer parts, stem packing.

Part 2 Products

2.1 Materials and Equipment

- A. Provide valves and appurtenances as specified and as shown on the drawings, and suitable for the service intended. Valves, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.
- B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.
- C. Standard Products
 - 1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.
- D. Identification and Tagging:
 - 1. Valves shall be marked in accordance with MSS SP-25 and shall bear an identification tag securely attached using No. 12 AWG copper wire, stainless steel wire, chrome-plated beaded chain or plastic straps designed for that purpose. Identification tags shall be 1.5 inch minimum diameter, made of engraved anodized aluminum or stamped stainless steel. Indentations shall be black for reading clarity. The service, valve identification number shown on the Valve Schedule in the contract drawings, the manufacturer's name, and the valve model number shall be displayed.

2.2 Valves

- A. General Requirements for Valves
 - 1. Valves shall include operator, actuator, handwheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and all other accessories required for a complete operation from the intended operating level.
 - 2. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified.
 - 3. Valves shall be the same size as adjoining pipe, unless otherwise noted.
 - 4. Valve ends shall be compatible with adjacent piping system.
 - 5. An operator shall be sized to operate the associated valve for the full range of pressures and velocities.
 - 6. Valves will open by turning counterclockwise.
 - 7. Operators, actuators, and accessories shall be factory mounted.

8. All exterior nuts, bolts, fasteners, etc. shall be stainless steel or other non-corrosive material.
- B. Valve Schedule: Submit a list of valve materials, pressure ratings, valve operator materials, electrical service, location, source of supply, and reference identification as indicated in the contract drawings. Provide a list of any special tools necessary for each valve type and appurtenances furnished for adjustment, operation, maintenance, and disassembly. Requirements relative to this paragraph are shown on the Valve Schedule located in the contract drawings.
- C. Factory Finishing: Valves shall have an epoxy coating in accordance with AWWA C550 unless otherwise specified. The epoxy shall be either a two-part liquid material or a heat-activated (fusion) material except that only a heat-activated material shall apply if a valve coating is specified as "fusion" or "fusion bonded" epoxy. The epoxy shall have a minimum 7.0 mils dry film thickness except where it is limited by valve operating tolerances. Exposed valves shall be finished in accordance with Section 09 90 15 – Paints.

2.3 Materials

- A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.
 1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139 (Alloy UNS No. C51000), B584 (Alloy UNS No. C90400 or C94700), B164, B194, and B127.
 2. Stainless steel alloy 18-8 may be substituted for bronze.
- B. Valve materials in contact with or intended for drinking water service to meet the following requirements:
 1. Comply with requirements of the Safe Drinking Water Act, including lead free requirements, and other applicable federal, state, and local requirements.
 2. Coatings materials to be formulated from materials deemed acceptable to NSF61.

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

B. Valve Locations

1. Valves shall be located in accordance with the contract drawings. Valves shall be located and oriented to permit easy access to the valve operator and or actuator, and to avoid interferences.

3.3 Valve Installation

- A. Flanged valve bolt holes shall be installed so as to straddle the vertical centerline of pipe. Flanged faces shall be cleaned prior to inserting the gasket and bolts, and then the nuts shall be tightened progressively and uniformly. Threaded ends shall have the threads cleaned by wire brushing or swabbing prior to installation.

B. Valve Orientation

1. The operating stem of a manual valve shall be installed in a vertical position when the valve is installed in horizontal runs of pipe having centerline elevations 4.5 feet or less above finished floor, unless otherwise shown on contract drawings. The operating stem of a manual valve shall be installed in a horizontal position in horizontal runs of pipe having centerline elevations between 4.5 feet and 6.75 feet above finish floor, unless otherwise shown on contract drawings. Automatic valves shall be installed in accordance with the manufacturer's instructions and approved drawings.
 2. Butterfly Valves: Orientation of butterfly valves shall take into account changes in pipe direction. Valve shafts shall be oriented so that unbalanced flows caused by pipe direction changes or other disturbances are equally divided to each half of the disc.
 3. Plug Valves: If a plug valve seat position is not shown in the contract drawings, locate the seat position as follows: for horizontal flow, the flow shall produce an "unseating" pressure, and the plug shall open into the top half of valve; and for vertical flow, the seat shall be installed in the highest portion of the valve.
- C. Chain Wheel and Guide: Chain wheel and guide assemblies or chain lever assemblies shall be installed on manually operated valves located over 6.5 feet above finished floor elevation. Where chains hang in normally traveled areas, appropriate "L" type tie-back anchors shall be used.

3.4 Valve Testing

- A. Submit copies of all field test reports within 24 hours of the completion of the test.
- B. Valves may either be tested while testing pipelines, or as a separate step.
- C. Demonstrate that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications.

Common Requirements for Process Valves

- D. Count and record the number of turns required to open and close each valve, and account for any discrepancies with manufacturer's data.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. This specification covers the requirements for actuators, both manual and electric, for above and below grade liquid process valves located both inside and outside of treatment plants.
- B. Valve manufacturer shall be responsible for mounting actuators on valves supplied under other sections. Valve manufacturer shall be responsible for coordinating the orientation and mounting of the actuators.

1.2 Related Sections

- A. Section 40 05 62 - Plug Valves.
- B. Section 40 05 63 - Ball Valves.
- C. Section 40 05 64 - Butterfly Valves.

1.3 Submittals

- A. Submit in accordance with Section 01 33 00.
- B. Shop Drawings:
 - 1. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - 2. Power and control wiring diagrams, including terminals and numbers.
 - 3. For each power actuator provided, Manufacturer's standard data sheet, with application specific features and options clearly identified.
 - 4. Sizing calculations for open-close / throttle and modulating valves.
- C. Manufacturer's Certificate: Submit Manufacturer's Certificate of Compliance for:
 - 1. Electric actuators: full compliance with AWWA C542.
- D. Operations and Maintenance Data: As specified in Section 01 78 23.
 - 1. Submit 6 copies each of operation and maintenance manuals in indexed booklet form. Detail in the Operation Manuals the step-by-step procedures required for specialized startup, operation and shutdown of piping systems, and include the manufacturer's name, model number, parts list and brief description of piping equipment such as valves and other appurtenances and their basic operating features.

2. List in the Maintenance Manuals routine maintenance procedures and troubleshooting guides for the equipment.

Part 2 Products

2.1 Materials and Equipment

- A. Provide valve actuators as specified and as shown on the drawings, and suitable for the service intended.
- B. All actuator components shall be identical products of the same manufacturer.
- C. Standard Products
 1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years.

2.2 Actuators

- A. Operator Schedule: Requirements relative to this paragraph are shown on the Operator Schedule located in the contract drawings.
- B. Manual Operators:
 1. The force in a manual operator shall not exceed 40 pound under any operating condition, including initial breakaway. The operator shall be equipped with gear reduction when force exceeds 40 pound. The manual operator shall be a self-locking type or shall be equipped with a self-locking device. A position indicator shall be supplied on quarter-turn valves. Worm and gear operators shall be a one-piece design with worm-gears of gear bronze material. Worm shall be hardened alloy steel with the thread ground and polished. Traveling nut type operators shall have threaded steel reach rods with an internally threaded bronze or ductile iron nut.
 2. Exposed Operators: Exposed operators shall have galvanized and painted handwheels. Cranks shall be supplied on gear type operators. If located off of the operator floor, chain wheel operator with tiebacks, extension stem, floor stands, and other accessories shall be provided to permit operation from normal operation level. Valve handles shall be capable of padlocking, and wheels shall be lockable with a chain and padlock.
- C. Electric Motor Operators
 1. Electric operators shall be provided complete with actuators, speed controls and accessories. Actuators shall comply with AWWA C542. The actuators shall operate on 460V, 3phase, 60 Hz with a 75 percent duty cycle and shall be equipped with an AC thermal overload protector with automatic rest, reversing (bi-directional) operation for use with quarter-turn valves, or rotating equipment to full rotation. Gearing shall be a two-stage planetary, permanently lubricated

self-locking gear train with self-lubricating bearings, connections via male output staff. A side mounted hand turn wheel shall be provided for a manual override. The actuators shall have a NEMA 250 Type 4 enclosure with a corrosion resistant, baked epoxy finish as standard. The actuator shall operate in a temperature range of -40 to plus 150 degrees F. Actuators shall fail in last position unless otherwise indicated. Electric operators shall be furnished with features noted on the Valve Schedule in the contract drawings.

2. Positioners. The positioners for modulating actuators shall control valve positions as a function of the input signals. The positioner shall operate on 120 VAC, 60 Hz. voltage. The mode of operation shall be direct acting. Modulating valve positioners shall operate on a 4 to 20 mA input signal unless otherwise indicated. Corrosion-resistant enclosures for positioners shall be splash-and moisture-proof with gasketed covers.
3. Acceptable Manufacturers/Products:
 - a. Rotork Controls IQ or IQT,
 - b. EIM M2CP,
 - c. Limitorque QX

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. Eccentric Plug Valves for Liquid Service.

1.2 Related Sections

- A. Section 09 90 15 – Paints.
- B. Section 40 05 51 - Common Requirements for Process Valves.
- C. Section 40 05 57 - Actuators for Process Valves and Gates.

Part 2 Products

2.1 Eccentric Plug Valves for Liquid Service

- A. Type 201, Eccentric Plug Valve, 3-inch thru 12-inch
 1. Nonlubricated type eccentric valves, 3 inch thru 12 inch, shall be rated for 175 psig service at 140 degrees F. Valves shall have drip-tight shutoff with pressure from either direction, and cast iron bodies. Exposed service valves shall have flanged ends in accordance with ASME B16.1 flanged end connections.
 2. Plug shall be all metal, matching body with round or rectangular port with no less than 80% of connecting pipe area and coated with Buna-N, welded nickel seats, self-lubricating stainless steel stem bearings, and stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, with grit seals on both upper and lower bearings. Valves shall be equipped with totally enclosed, geared, manual operator with handwheel. Size operator for 1.5 times the maximum shutoff pressure differential for direct and reverse pressure, whichever is higher.
 3. Manufacturers and Products:
 - a. DeZurik Style PEC,
 - b. Valmatic Style 5800R,
 - c. Pratt Ballcentric,

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. Metal and Plastic Ball Valves

1.2 Related Sections

- A. Section 40 05 51 - Common Requirements for Process Valves.

Part 2 Products

- A. Type V401, General Purpose Ball Valves, 2 inch and smaller, for Potable Water Service.

- 1. Ball valves, 2 inch and smaller, shall be end entry type with bronze bodies and threaded, in accordance with ASME B1.20.1, regular ports. Valves shall have polytetrafluoroethylene (PTFE) seats and packing, hard chrome plated brass balls and hand lever operators. Valves shall be rated for 600 psig WOG and shall conform to MSS SP-110. A union shall be installed adjacent to the valves to provide access to the seat.

- 2. Acceptable Manufacturers and Products:

- a. Threaded:

- 1) Conbraco Apollo 7OLF-100
- 2) Nibco T-580-LF
- 3) Or Approved Equal

- b. Soldered:

- 1) Conbraco Apollo 7OLF-200
- 2) Nibco S580-LF
- 3) Or Approved Equal

2.2 Plastic Ball Valves

A. Type V403, PVC Ball Valve

1. Thermoplastic ball valves, 2 inch and smaller, shall be rated for 150 psig service at 120 degrees F, and have ASTM D1784, Type 1, Grade 1 polyvinyl chloride (PVC) bodies, balls, and stems. Valves shall be end entry, double union design, with solvent-weld socket ends connections, a fluoro-elastomer seat, and fluoro-elastomer or polytetrafluoroethylene (PTFE) O-ring stem seals. Valves shall have hand lever operators. Provide pressure relief hole drilled on low pressure side of ball.
2. Manufacturers and Products:
 - a. Nibco, Chemtrol Tru-Bloc,
 - b. Asahi/America, Type 21,
 - c. Spears, True Union,

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. AWWA Resilient-Seated Butterfly Valves

1.2 Related Sections

- A. Section 09 90 15 – Paints.
- B. Section 40 05 51 - Common Requirements for Process Valves.
- C. Section 40 05 57 - Actuators for Process Valves and Gates.

Part 2 Products

2.1 AWWA Resilient-Seated Butterfly Valves

A. General

1. Butterfly valves for liquid service shall be in full compliance with AWWA C504 and the following requirements:
 - a. Valves shall be suitable for throttling operations and for infrequent operations after periods of inactivity.
 - b. Valves shall be bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
 - c. Provide self-adjusting V-type or O-ring shaft seals.
 - d. Isolate metal-to-metal thrust bearing surfaces from flow stream.
 - e. Provide traveling nut or worm gear with electric actuator. Valve actuators shall meet all requirements of AWWA C504.

B. Type V500 AWWA Resilient Seated Butterfly Valve, 3" to 24"

1. Butterfly valves shall have ASTM A126 cast iron or ductile iron bodies, short-body style with ASME B16.1 flanged end connections. Valves shall conform to AWWA C504 Class 150B. Discs shall be contoured ASTM A436 Type 1 Ni-resist cast iron with maximum lead content of 0.003 percent or ASTM A536 Grade 65-45-12 ductile iron. The valve shafts shall be stainless steel with self-lubricating, corrosion-resistant sleeve type bearings. Valve seats for 24 inch and smaller valves shall be attached to either the valve body or the disc and shall be constructed of Buna-N rubber.

2. Manufacturers and Products:
 - a. DeZurik.
 - b. Pratt Triton XR-70,
 - c. Valmatic Series 2000,

Part 3 Execution

3.1 Examination

- A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

- A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

END OF SECTION

Part 1 General

1.1 Work Required

- A. All piping, valves, fittings, conduit, panels, process equipment, accessories, etc., installed as part of this project shall be identified, color coded, stenciled or tagged as described herein or elsewhere in these Contract Documents and as required by OSHA, State and local safety codes.
- B. Exposed piping, valves, fittings, conduit, accessories, etc., shall conform to ANSI A13.1 color coding and identification system. Items shall be considered exposed unless buried or embedded in the construction. Insulated piping shall be color-coded as required for the carrier pipe.
- C. Buried or concealed equipment, devices, controls, piping, valves, fittings, conduit, accessories, etc., shall also be identified and provided with locating devices. Piping shall be identified in conformance with the color coding schedule.
- D. All valves shall be provided with identification tags.

1.2 Related Work Specified Elsewhere

- A. Section 09 90 15 – Paints

1.3 Contractor Submittals

- A. Submittals shall be made in accordance with Section 01 33 00.
- B. The following submittals and specific information shall be provided:
 - 1. Samples of all types of identification devices to be used in the work.
 - 2. Technical product data and installation instructions for each identification material and device required.
- C. The Contractor shall submit to the Engineer, for approval, a list of suggested wording for all valve tags prior to fabrication. Upon approval, provide a complete list of all tagged valves (valve schedule) giving tag symbol (code and number), color, shape, location, use, type, size, pressure rating, and manufacturer's name.

1.4 Quality Assurance

- A. **Manufacturers Qualifications:** Firms regularly engaged in manufacture of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.

Part 2 Products

2.1 Identification of Exposed Piping

- A. All exposed piping and piping in accessible chases and areas above ceilings with panels, excluding stainless steel, shall be completely and totally painted for identification purposes as scheduled below.
- B. Each pipe identification shall consist of color coding in accordance with Paragraph 3.3 IDENTIFICATION SCHEDULE.
- C. For piping 8" in diameter and smaller, provide plastic pressure-sensitive adhesive labels or plastic clip-on type markers with legends and/or symbols as approved by the Owner. Arrows indicating direction of flow shall point away from legend. If flow may be both ways, use double-headed arrows. Background color shall be as recommended by ANSI A13.1 and approved by Owner. Markers for pipe and conduits shall be as follows:

| Outside Diameter (Inches) | Minimum Letter Size (Inches) |
|------------------------------|---------------------------------|
| ¾ to 1-¼ | ½ |
| 1-½ to 2 | ¾ |
| 2-½ to 6 | 1-¼ |
| 8 | 1-½ |

- D. For piping larger than eight inches in diameter, the identification shall be by stenciling. Letters shall be black on piping that is painted light colors and white on piping that is painted dark colors. Letter and number sizes shall be ½ the diameter of the pipe up to a maximum letter or number size of 6 inches. Provide a painted label and a directional flow arrow. Where color bands are required, the painted label and directional arrow shall be placed between color bands. When more than one color band is used the different color bands shall be painted adjacent. Piping identification shall be located in accordance with Paragraph 3.2 PIPE IDENTIFICATION LOCATION.
- E. **Color Bands and Arrows:** Where color bands are required, color band size shall be as follows:
- | | |
|---------------------------|----------------------|
| Pipe Size | Color Band Size |
| less than 1" diameter | 1" wide |
| 1" to 12" diameter | 1 pipe diameter wide |
| greater than 12" diameter | 12" wide |

| | |
|---------------------------|-----------------|
| Second Band: | |
| less than 1" diameter | ½" wide |
| 1" to 12" diameter | ½ pipe diameter |
| greater than 12" diameter | 6" wide |

- F. For cases where there are insulated lines wrapped with aluminum sheathing, stainless steel sheathing, or gray fabric, the background color shall be applied to a 24 inch length of pipe section and color band centered within the 24 inch field of background color.
- G. Paint Colors: Paint colors shall conform to the following designations:

| Color | Federal Standard 595 Number |
|--------------------------|-----------------------------|
| Light Blue | 15200 |
| Aqua | 35275 |
| Blue | 15183 |
| Dark Blue | 15102 |
| Red | 21105 |
| Yellow | 13655 |
| Orange | 32473 |
| White | 17875 |
| Light Brown (Tan) | 30257 |
| Dark Brown | 20062 |
| Light Green | 34552 |
| Olive Green | 14087 |
| Green | 14062 |
| Black | 17038 |
| Silver | 17178 |
| Grey | 26152 |
| Purple | 17100 |
| Purple – Reclaimed Water | Pantone 512C |

2.2 Identification of Underground Pipe

- A. Underground metallic pipe and tube shall be located by laying 3-inch wide, minimum, plastic flagging tape continuously along the run of pipe or tubing. Tape shall be laid directly over the pipe and no closer than 12 inches to the top of pipe. The tape shall be a minimum of 4 mil inert polyethylene and be color-coded and stenciled as required for the item being identified.
- B. Underground non-metallic pipe and tube shall be located by laying 3-inch wide, minimum, plastic/metal impregnated flagging tape continuously along the run of pipe or tubing. Tape shall be laid directly over the pipe and no closer than 12 inches to

the top of pipe. The tape shall be a minimum of 4 mil inert polyethylene/aluminum foil composite and be color-coded and stenciled as required for the item being identified.

2.3 Identification of Valves

- A. Valves shall be marked in accordance with MSS SP-25 and shall bear an identification tag securely attached using stainless steel wire designed for that purpose. Identification tags shall be 1.375 inch minimum diameter, made of engraved stamped stainless steel.
- B. The size, valve type, service, and valve identification number as shown on the Valve Schedule in the contract drawings shall be displayed.
- C. Valve tags for underground valves shall be permanently affixed to the concrete pad surrounding the valve box.

2.4 Existing Identification Systems

- A. In installations where existing piping identification systems have been established, the Contractor shall continue to use the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the specified system. The objective is to fully identify all new piping, valves and appurtenances to the level specified herein.

2.5 Identification of Pipe 5/8 Inch or Smaller

- A. Where the outside diameter of pipe or pipe covering is 5/8 inch or smaller, metal tags shall be provided instead of lettering. Tags shall have the specified identifying lettering stamped in the tag and shall be fastened to the pipe with suitable chains. Metal tags and chains shall be aluminum or stainless steel. Where tags are used, pipe shall be color coded as specified in Paragraph 3.3.

Part 3 Execution

3.1 General

- A. All labels and identification tags shall be installed in accordance with the manufacturer's printed instructions and shall be neat and uniform in appearance. All such tags or labels shall be readily visible from all normal working locations.

3.2 Pipe Identification Location

- A. Straight lines of pipe shall be identified at intervals of 20 feet maximum, and at least once in each room unless otherwise directed by the Engineer.

- B. Piping shall also be identified at a point approximately within 2 feet of all turns, ells, valves, and on the upstream side of all distribution fittings or branches and on both sides of each floor, wall or barrier through which the line passes.
- C. Sections of pipe that are too short to be identified with color bands, lettered labels, and directional arrows shall be tagged and identified similar to valves.

3.3 Identification Schedule

- A. Application of identifying devices shall conform to the following color codes, or match existing color code as directed by the Engineer.

| MATERIAL IN PIPE | BACKGROUND COLOR/BAND COLOR(S) |
|----------------------------|---|
| Settled or Clarified Water | Aqua |
| Potable Water | Dark Blue |
| Non-potable Water | Blue/Black |
| Filtered (Effluent) | Blue |
| Sample Line | same as line or equipment being sampled |

END OF SECTION

Part 1 General

1.1 Work Included

A. Filter Operator Consoles/PLC/HMI

1. Provide a Programmable Logic Controller (PLC) and HMI Operator Interface Station for each filter.
2. Setup Backwash and Filter Controls at the HMI for each filter.
3. Connect the Operator Console PLC's to the existing SCADA system. Connect to NK3 SCADA cabinet using CAT6 ethernet connections.
4. The PLC's for the 1949 filters shall be installed in the existing consoles. The HMI screen shall be installed in an enclosure mounted to the top of the console and connected to the PLC via a CAT6 cable.
5. The PLC's for the 1969 filters shall be installed in new freestanding operator consoles. Controls for Filters 5 and 6 shall be installed in one common console. Controls for Filters 7 and 8 shall be installed in one common console. All filters shall include a dedicated PLC and HMI screen.
6. Each filter shall have an automatic/manual selection on the HMI screen. In manual mode, all associated valves shall be operator controllable from the HMI touchscreen. In auto and manual mode, the valve position should be displayed. The status of the filter should also be displayed on the HMI screen. This includes the status when the filter is in Backwash Mode.
7. In automatic mode, the filter should automatically Backwash when required. The PLC shall control all valves and monitor the turbidity, flow, head loss and level data. In Rewash cycle the turbidity level of the waste stream is measured. If the required turbidity level does not fall below the maximum turbidity level allowed after a designated time (Operator adjustable - default of 20 minutes), then an alarm should be shown on the HMI Screen and transmitted to the SCADA system.
8. Filters require a LOW and HIGH backwash rate. The filter PLC should communicate with the PLC for filter #7 to change the flow rate setpoint for the Backwash flow valve. The system should be set for four different flow rates based upon the filter being backwashed. The LOW and HIGH rates differ for the 1949 filters and the 1969.
9. The turbidity, effluent flow, and filter Loss of Head shall be displayed on the HMI screen for each filter.

B. SCADA System

1. Integrate new Filter Operator Consoles and controls into the existing SCADA system.
2. Provide Monitoring of all parameters at the SCADA Operator Terminals. Provide updated graphics and new screens.

1.2 Definitions

- A. Definitions, Symbols, and engineering unit abbreviations shall conform to IEEE Standards Dictionary, as applicable.

1.3 Submittals

- A. Submit the following in accordance with Section 01 33 00 - Submittal Procedures. Partial submittals will not be accepted.
- B. Submit proposed submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
- C. Bill of Materials: List of required equipment.
1. Group required equipment items by process area and enclosure, and within an enclosure as follows:
 - I. Process Control Components: By component identification code.
 - II. Other Equipment: By equipment type.
 2. Data required:
 - I. Equipment tag number.
 - II. Description.
 - III. Manufacturer, complete model number, and all options not defined by model number.
 - IV. Quantity supplied.
 - V. For panels, include panel reference number and name plate inscription.
- D. Catalog Cut Sheets: For all process control components, electrical devices, and mechanical devices:
1. Catalog information, clearly marked to identify proposed items and options provided.
 2. Descriptive literature.

3. External power and signal connections.
 4. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
- E. Component Data Sheets: For all process control components.
1. Format: Similar to ISA TR20.00.01. Submit proposed format for Component Data Sheets before completing data sheets for individual components. Submit in electronic format (Microsoft Excel compatible) with one component per data sheet.
- F. Panel Construction Drawings:
1. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, and subpanels, both internal and external.
 2. Panel Legend (Bill of Materials): List front of panel devices by tag numbers, nameplate inscriptions, and service legends.
 3. Bill of Materials: List devices mounted within panels which are not listed in panel legend. Include tag number, description, manufacturer, and model number.
 4. Construction Details: NEMA rating, materials, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other construction callouts and details.
 5. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.
- G. Panel Wiring Diagram:
1. Cover wiring within a panel including, but not limited to, instrumentation, control, power, communications, and digital networks. Provide information for wiring panels, making panel connections, and future panel trouble shooting.
 2. Diagram Type:
 - I. Ladder diagrams where applicable. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.
 - II. Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.
 - III. Item identification: Identify each item with attributes as listed below.
 - 1) Wires: Wire number and color. Cable number if part of a multi-conductor cable.

- 2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
 - 3) Components
 - a) Tag number, terminal numbers, and location ("FIELD", enclosure number, or MCC number).
 - b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description.
 - 4) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
 - 5) 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. Clearly indicate normally closed contacts.
 - 6) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
 - 7) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.
- IV. Show each circuit individually. No "typical" diagrams or "typical" wire lists will be allowed.
- V. Wire and Cable Names: Show names and wire colors for circuits entering and leaving a panel.
- H. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog, discrete, or equipment loop.
1. Conform to requirements of ISA S5.4.
 2. Show loop components within a panel and identify each component, component terminals, and panel terminals.
 3. If a loop connects to panels or devices not provided under this Section and its related sections, such as control valves, motor control centers, package system panels, and variable speed drives, provide the following information:
 - I. Show the first component connected to within the panel or device that is not provided under this Section and its subsections.

- II. Identify the component by tag and description.
- III. Identify panel and component terminal numbers.
- 4. Provide one drawing per I/O module. Show all PLC I/O. No “typical” loop diagrams will be allowed.
- 5. Show:
 - I. Terminal numbers, location of dc power supply, and location of common dropping resistors.
 - II. Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
 - III. Tabular summary on each analog loop diagram:
 - 1) Transmitting Instruments: Output capability.
 - 2) Receiving Instruments: Input impedance.
 - 3) Loop wiring impedance: Estimate based on wire sizes and lengths shown.
 - 4) Total loop impedance.
 - 5) Reserve output capacity.
 - IV. Circuit and raceway schedule names.
- 6. Drawing Size: Individual 11-inch by 17-inch sheet.
- I. Communications Networks Diagrams:
 - 1. Include connections to Ethernet network.
 - 2. Network schematic diagrams for each different type of network.
 - 3. Show:
 - I. Interconnected devices, both passive and active.
 - II. Device names and numbers.
 - III. Terminal numbers.
 - IV. Communication Media: Type of Cable.
 - V. Connection Type: Type of connector.
 - VI. Node and device address numbers.

VII. Wire and cable numbers and colors.

- J. Panel Power Requirements and Heat Dissipation: For control panels, tabulate and summarize:
 - 1. Required voltages, currents, and phases.
 - 2. Maximum heat dissipation in Btu per hour.
 - 3. Steady State Temperature Calculations: For non-ventilated panels, provide heat load calculations showing the panel estimated internal steady state temperatures for ambient air temperatures of 90 degrees F.
- K. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for:
 - 1. Pipes and tubes: Thickness, pressure rating, and materials.
 - 2. Components – valves, regulators, and filters.
 - 3. Connections to panel-mounted devices.
 - 4. Panel interface connections.
- L. Installation Details: Include modifications or further details required to define installation of process control components.
- M. List of Spares, Expendables, and Test equipment.
- N. PLC I/O List.
- O. Informational Submittals:
 - 1. Statements of Qualifications
 - I. Instrumentation and Controls Subcontractor's site representative.
 - 2. Operation and Maintenance Data: In accordance with Section 01 78 23 and the following:
 - I. General: Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, and maintenance and purchasing replacements for process control components.
 - II. Include the following items as defined above:
 - 1) Bill of materials.
 - 2) Catalog cut sheets.
 - 3) As-built Detailed Wiring Diagrams:

- a) Panel wiring diagrams.
 - b) Loop diagrams.
 - 4) Panel Plumbing Diagrams.
 - 5) Application software documentation.
 - III. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices.
 - IV. List of spares, expendables, test equipment and tools provided.
 - V. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.
- P. Testing Related Submittals:
- 1. Performance Verification Test (PVT) Factory Test Procedure
 - I. Proposed test procedures, forms, and checklists.
 - II. Capacity, Timing, and Simulation: Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.
 - 2. Factory Test Reports for Testing, Adjusting and Commissioning Performance Verification Test (PVT) and Endurance Test.
 - 3. Equipment Communications Test:
 - I. Test procedures, forms, and checklists.
 - II. Test reports.
 - 4. Component Acceptance Test:
 - I. Test procedures, forms, and checklists.
 - II. Test reports.

1.4 Field Training

- A. Field training oriented to the specific system shall be provided for designated personnel.
- B. Furnish a copy of the training manual for each trainee plus two additional copies.
- C. Manuals shall include an agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson.

- D. Furnish audiovisual equipment and other training supplies and materials. Copies of the audiovisuals shall be delivered with the printed training manuals.
- E. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.
- F. Submit the training manual and schedule to receive approval from the Engineer at least 30 days before the training.
- G. Preliminary Operator Training
 - 1. Prior to the start of field testing, preliminary operator training shall be taught at the project site for 1 training day.
 - 2. Upon completion of this course, each student, using appropriate documentation, should be able to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system.
 - 3. This course shall include: general system architecture; functional operation of the system, including workstations; operator commands; application programs, control sequences, and control loops; database entry and modification; reports generation; alarm reporting; diagnostics; and historical files.
- H. Additional Operator Training
 - 1. Following the field testing, additional classroom training for operators shall be taught for 1 training day; individual instruction sessions of 4 -hour periods in the morning (or afternoon) of the same weekday and an additional 1 day classroom session for answering operator questions.
 - 2. Individual instruction shall consist of "hands-on" training under the constant monitoring of the instructor.
 - 3. Classroom training shall include instruction on the specific hardware configuration of the installed control system and specific instructions for operating the installed system.
 - 4. Schedule activities during this period so that the specified amount of time on the equipment will be available for each student.
 - 5. The final session will address specific topics that the students need to discuss and to answer questions concerning the operation of the system.
 - 6. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed control system.
 - 7. Each student should be able to start the system, operate the system, recover the system after a failure and describe the specific hardware architecture and operation of the system and be fully proficient in all system operations.

8. Report the skill level of each student at the end of this course.
- I. Maintenance Training
 1. Following the endurance test, a minimum period of one training days shall be provided by a factory representative or a qualified Contractor trainer for designated personnel on maintenance of the equipment.
 2. The training shall include: physical layout of each piece of hardware, calibration procedures, preventive maintenance procedures, schedules, troubleshooting, diagnostic procedures and repair instructions.

1.5 SCADA System Integrator

The system integrator procured by the Owner shall provide the integration for the existing NK3 control cabinet and operator station. The integrator shall work with the filter vendor to mimic the controls and instrumentation shown at the operator console HMI.

Part 2 Products

2.1 System Description

- A. The process instrumentation and control system shall be used to monitor and control the filters 1-8 in the 1949 and 1969 sections of the WTP. The control system shall provide for operator interaction, overall control system supervision, and process equipment control and monitoring.
- B. Provide hardware configured and sized to support expansion as specified and shown on the drawings.
- C. Loop Descriptions: See Appendix A.
- D. Instrumentation Schedule: See Tables Following this Section.
- E. Operation
 1. The control system provided under this specification shall operate using direct digital control (DDC) algorithms or ladder logic type and supervisory control to provide the required sequences of operation.
 2. Input data to the controller shall be obtained by using instruments and controls interfaced to mechanical, electrical, utility systems and other systems as shown and specified.
 3. The number and location of control panels shown on drawings shall be provided as a minimum.

F. Points

1. Each connected analog output (AO), analog input (AI), digital output (DO), digital input (DI), pulse accumulator (PA) input and other input or output device connected to the control system shall represent a "point" where referred to in this specification.

G. Data Transmission Systems (DTS)

1. Provide data transmission systems for communication between PLCs and the central station as specified in Section 26 05 23 – Control Voltage Electrical Power Cables and as indicated.

2.2 Materials and Equipment

- A. Standard Products: Materials and equipment must be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment shall be products of a single manufacturer. Items of the same type and purpose shall be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Engineer.

B. Nameplates:

1. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place.
2. Laminated plastic nameplates shall be provided for equipment devices and panels furnished. Each nameplate shall identify the device, utilizing the designations shown on the P&ID's, such as pump "P-1001" or valve "V-0012".
3. Labels shall be coordinated with the schedules and the process and instrumentation drawings.
4. Laminated plastic shall be 1/8 inch thick, white with black center core.
5. Nameplates shall be a minimum of 1 by 3 inches with minimum 1/4 inch high engraved block lettering.
6. Nameplates for devices smaller than 1 by 3 inches shall be attached by a nonferrous metal chain. All other nameplates shall be attached to the device.

2.3 General Requirements

- A. Equipment located outdoors, not provided with climate controlled enclosure, shall be capable of operating in the ambient temperature range indicated in paragraph ENVIRONMENTAL CONDITIONS, unless otherwise specified.
- B. Electrical equipment will conform to Division 26. Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental

conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.4 Coordination

- A. Systems supplied under this specification shall be designed and coordinated for proper operation with related equipment and materials furnished by other suppliers under documents and, where applicable, to related existing equipment. All equipment shall be designed and installed in full conformity with the drawings, specifications, engineering data, instructions and recommendation of the manufacturer, and the related equipment manufacturer.
- B. Related Equipment and Materials
 - 1. Related equipment and materials may include, but will not be limited to, instrumentation, motor controllers, valve actuators, chemical feeders, analytical measuring devices, conduit, cable, and piping as described in other specifications associated with this project.
- C. Drawing Submittals
 - 1. Review of drawings submitted prior to the final determination of related equipment shall not relieve the system supplier from supplying systems in full compliance with the specific requirements of the related equipment.
 - 2. Installation drawings shall be prepared for interconnecting wiring between the related equipment and equipment furnished under these sections. All interconnecting wiring shall be appropriate for the service and shall result in a properly operating system.
- D. Other Contractors
 - 1. Coordination with other contractors and supervision of installation shall be provided by the system supplier as required during construction.

2.5 Monitoring and Control Parameters

- A. The control system shall be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, engineering units conversions and algorithms for the applications; and shall maintain the specified end-to-end process control loop accuracy from sensor to display and final control element.
- B. Control equipment shall be powered by a 120 V ac, single phase, 60 Hz power source, with local transformers included as needed for signal transmission and subsystem operation.
- C. Connecting conductors shall be suitable for installed service.

2.6 Control Panels

- A. Components

1. Enclosures: The enclosure for each control panel shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. Enclosures for installation in mechanical equipment rooms shall be Type 4; those for installation in clean, dry indoor occupied space may be Type 1; other locations shall be as otherwise specified or shown. Enclosures for equipment installed outdoors shall be Type 4 or as shown. Enclosures for installation in a corrosive environment shall be Type 4X and shall be constructed of stainless steel. Painted steel shall not be allowed for use in a corrosive environment. Enclosure shall be provided with a single, continuously hinged exterior door with print pocket, 3-point latching mechanism and key lock and a single, continuously hinged interior door. Enclosures shall be marked with UL508A label.
2. Standard Indicator Light: Indicator lights shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Lights shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. Indicator lights shall be LED type and shall operate at 120 V ac or 24 V dc. Indicator light shall be provided with a legend plate labeled as shown on the drawings. Lens color shall be as indicated on the drawings.
3. Selector Switches: Selector switches shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Selector switches shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. The number of positions shall be as indicated on the drawings. Switches shall be non-illuminated or as indicated on the drawings. Switches shall be rated for 600 volts, 10 amperes continuous. Selector switches shall be provided with a legend plate labeled as shown on the drawings. Where indicated or required, dual auxiliary contacts shall be provided for the automatic position to provide position sensing at the central station or workstation. Auxiliary contacts shall be rated for 120 V ac, 1A as a minimum. Where indicated on the drawings, switches shall be key operated. All keys shall be identical.
4. Push Buttons: Push buttons shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Push buttons shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. The number and type of contacts shall be as indicated on the drawings or required by the Sequence of Control. Push buttons shall be rated for 600 volts, 10 amperes continuous. Push buttons shall be provided with a legend plate labeled as shown on the drawings.
5. Relays: Relays shall comply with IEEE C37.90. Relays shall be as required by the Sequence of Control]. Relay coil shall be provided with matching mounting socket. Power consumption shall not be greater than 3 watts.
6. Terminal Blocks: Terminal blocks shall comply with NEMA ICS 4 and UL 1059. Terminal blocks for conductors exiting control panels shall be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks shall be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip shall form part of the terminal block and each terminal shall be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

7. Alarm Horns: Alarm horns shall be provided where indicated on the drawings. Horns shall be vibrating type and shall comply with UL 508. Horns shall provide 100 dB at 10 feet. Exterior mounted horns shall be weather proof by design or shall be mounted in a weather proof enclosure that does not reduce the effectiveness of the horn.
- B. Panel Assembly: Control panels shall be factory assembled and shipped to the jobsite as a single unit. Panels shall be fabricated as indicated and devices shall be mounted as shown or required. Each panel shall be fabricated as a bottom-entry connection point for control system electrical power.
- C. Electrical Requirements: Each panel shall be powered by a dedicated 120 volts ac circuit, with a fuse, sized as recommended by the equipment manufacturer, and a disconnect switch located inside the panel. Wiring shall terminate inside the panel on terminal blocks. Electrical work shall be as specified in Division 26 and as shown on the drawings.
- D. Surge Arresters
 - I. Surge and lightning arresters shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type with a response time of less than 50 nanoseconds. Surge protective devices shall be applied for the following:
 - 1) All power connections to PLCs and control equipment.
 - 2) All analog signal circuits for which any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and control system end of the circuit.
 - 3) All metallic media local area network termination points, for which any part of the cable is routed outside of the building envelope.
- E. Power Line Conditioner: Each control panel shall be provided with a power line conditioner to provide both voltage regulation and noise rejection. The power line conditioner shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The power line conditioner shall be sized for 125 percent of the actual connected kVA load. Characteristics of the power line conditioner shall be as follows:
 1. 85 Percent Load: At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.
 2. Load Changes: During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within 5 cycles, and 95 percent correction shall be accomplished within 2 cycles of the onset of the disturbance.

F. Grounding:

1. Control panel enclosures shall be equipped with a solid copper ground bus or equivalent. The ground bus shall be securely anchored to the enclosure so as to effectively ground the entire structure. Clamp-type terminals sized large enough to carry the maximum expected current shall be provided on the ground bus for grounding cables. Where a definite circuit ground is required, a single wire not less than #10 AWG shall run independently to the panel ground bus and shall be fastened to the ground bus with a bolted terminal lug.
2. Cases of instruments, relays and other devices shall be effectively grounded through the enclosures steel structure unless otherwise indicated. Insulated wiring having a continuous rated current of not less than the circuit fuse rating shall be used for grounding.
3. Grounding terminals of power receptacles shall be solidly grounded to the panel enclosure.

G. Convenience Outlet

1. A 120 volt ac, 20 amp, ground fault interruption (GFI) type duplex convenience outlet shall be provided inside the panel. The outlet circuit shall be separate from the panel power circuit.

H. Panel Interior Light: Each control panel[s] shall be provided with an LED light. The light shall be operated by a manual on-off switch mounted on the interior door of the enclosure. The light shall be powered by the same circuit as the convenience outlet

I. HMI Software

- 1) The system integrator shall configure new HMI software to incorporate the following number of owner approved displays.
 - a) Filter Display (8 filters total)
 - b) 15 Reports
 - c) 15 Trend Displays (up to 6 Points per Trend)

1.1 Control Panel Electrical

A. Wiring within Enclosures

1. For AC Circuits:
 - a. Type: 600-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than No. 14 AWG.

- B. For Analog Signal Circuits
 - 1. Type: 300-volt, Type 2 stranded copper, twisted shielded pairs.
 - 2. Size: No. 18 AWG, minimum.
- C. For other DC Circuits
 - 1. Type: 600-volt, Type MTW stranded copper.
 - 2. Size: No. 18 AWG, minimum.
- D. Separate analog signal and other DC circuits at least 6 inches from any AC power and control wiring.
 - 1. Enclose wiring in sheet metal raceways or plastic wiring ducts.
 - 2. Wire Identification: Numbered and tagged at each termination.
 - 3. Wire Tags: Machine printed, heat shrink.
- E. Wiring Interface
 - 1. For analog and discrete signals, terminate wiring at numbered terminal blocks.
 - 2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
 - 3. For panels, terminate wiring at equipment on/with which it is mounted.
- F. Terminal Blocks
 - 1. Quantity
 - a. Sufficient for all external connections, plus minimum 20 percent spare, but not less than 1.
 - b. Wire spare or unused panel mounted elements to their panels' terminal blocks.
 - c. General: Group terminals to keep 120V AC circuits separate from 24V DC circuits.
 - 2. Connection Type: Screw connection clamp.
 - a. Compression Clamp: Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection. Compression clamp guides strands of wire into terminal.
 - b. Screws: Hardened steel, captive, and self-locking.
 - c. Current Bar: Copper or treated brass.

- d. Insulation: Insulation shall be thermoplastic rated for minus 55 to plus 110 degrees C. Provide two funnel shaped inputs to facilitate wire entry.
3. Mounting
 - a. Rail.
 - b. Terminal block shall be designed to be extracted from an assembly without displacing adjacent blocks.
 - c. End Stops: Provide one at each end of rail, minimum.
 4. Wire Preparation: Stripping only.
 5. Jumpers: Allow jumper installation without loss of space on terminal or rail.
 6. Marking System
 - a. Terminal number shown on both sides of terminal block.
 - b. Allow use of preprinted and field marked tags.
 - c. Terminal strip numbers shown on end stops.
 - d. Mark terminal block and terminal strip numbers as shown.

2.7 Data Communication Requirements

- A. Control system data communications shall support the specified functions and control system configuration shown on the drawings.
- B. Central Station/Workstation: Each workstation shall be able to communicate with the central station as a virtual terminal. The workstation shall be able to initiate uploads or downloads of programs and resident data, including parameters of connected systems PLCs and devices, constraints and programs in the central station.
- C. Central Station/PLC: The central station shall be able to initiate an upload or download of PLC data programs.
- D. Modem Communication
 1. Communication with other computer systems shall be accomplished using a modem and dialup circuit. The central station or workstation shall be able to initiate upload or download of data files, however, answering incoming calls shall not be possible (for system security reasons).
 2. Error Detection and Retransmission: Asynchronous transmission system shall use cyclic code error detection methods. The predicted undetected error rate shall not exceed 1 bit in 1 billion. A message shall be in error if one bit is received incorrectly. The system shall retransmit messages with detected errors. Where a LAN is not utilized for data transmission, a 2-digit decimal

number shall be operator assignable to each communication link representing the number of retransmission attempts. When the number of consecutive retransmission attempts equals the assigned quantity, the central station shall close down transmission to that particular device, and print an alarm message. The operator shall manually reopen any communications line after automatic closedown, subject to the same error checking and automatic closedown procedures in effect before the first automatic closedown. The system shall monitor the frequency of data transmission errors for display and logging.

2.17 Programmable Logic Controller (PLC) System

A. General

1. Function: PLC configured to provide communications between PLC and workstation. Also, capable of logic functions such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
2. Type: Microprocessor based device programmable using ladder logic.
3. Parts: Central Processing Unit (CPU), power, supply, local and remote (if required) input/output modules, local and remote (if required), base controller, programming software and adapter modules, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system.

C. Power Supply

1. One unit for each input/output base assembly:
2. Voltage: 120 volts, 60 hertz; 85 to 132 volts output.
3. Mounting: Integral with base.

D. Input/Output

1. Complete input/output system
2. Modular, block type.

E. Identification

1. Nameplates installed above each PLC component (CPU, I/O rack, power supply, etc.)
2. Identify configured I/O points as they have been configured (addressed) in the system, as approved by the Engineer.

F. Programming Computer and Software

1. Use programming computer supplied as part of the project. Load programming software and provide all modules and ancillaries to make a completely operating system. Include all software and cables required for programming of PLC's.

G. Manufacturers and Products – PLC's

1. Design is based on the following PLC's. These are provided to convey the level of quality required of the system, as well as the capabilities.
 - a. In CP4: Allen-Bradley, CompactLogix
2. Cables
 - a. CAT6E cables shall be plenum rated and contain 4 pairs.
 - b. Fiber Optic cables shall have an overall polyamide jacket.
3. Ethernet Switches
 - a. Full duplex.
 - b. 100 MBIT/S
 - 1) 100 Base-FX (Fiber)
 - 2) 100 Base-TX (Copper)
 - a) Industrial Rated

2.18 Touch Screens

A. General

1. A color touch screen shall be mounted flush to the face of the control panel.
2. Touch screens shall be a minimum of 15 inches (diagonally measured).
3. Memory shall be a minimum of 128 MB RAM, 128 MB CF.
4. Resolution shall be a minimum of 1024 x 768.
5. Backlights shall be field replaceable (unless LED backlighting is used).
6. Touch screens shall be stand alone. All screens and programming shall reside on it.
7. Platform shall be open multi-application.

B. Electrical

1. Input Voltage: 120 V ±10 percent.
2. Power Consumption: 200 VA maximum.

1.1 Spare Parts

- A. As a minimum, the following spare parts and consumable items shall be provided.
1. One (1) spare module of each type used in the PLCs and Remote I/O, including CPU modules.
 2. One HMI Screen
 3. 100 percent spares for all lamps and fuses.

1.2 Software License

- A. All software programs supplied as a standard part of the system supplier's products furnished for this project shall be licensed to the Owner for his use on the system specified herein. Such license shall not restrict the Owner from use of the software provided on the system provided hereunder or its replacement. Owner shall be granted the right to make copies of the software as deemed necessary for use on the system provided. Specific requirements of the systems supplier's software license are subject to review and approval by the Owner and Engineer.

2.8 Factory Test

- A. The control system shall be tested at the factory prior to shipment. Written notification of planned testing shall be given to the Engineer and Owner at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written approval of the test procedures.
- B. Factory Test Setup

Assemble and integrate the factory test setup as specified to prove that performance of the system satisfies all requirements of this project, including system communications requirements in accordance with the approved test procedures.

1. The factory test shall take place during regular daytime working hours on weekdays.
2. Equipment used shall be the same equipment that is to be delivered to the site.
3. The factory test setup shall include the following:

| | |
|---------------------------|----------------------------|
| Factory Test | |
| Central Station Equipment | one each of the components |

Process Control

| | |
|----------------------------|--|
| Workstation | one of each type |
| Control Panel | not less than two control panels: at least one of each type used in the system plus at least one per DTS type |
| Test Set | one of each type |
| Portable Tester | one of each type |
| Communications Circuits | one of each type and speed to be utilized in the proposed system including bridges, modems, encoder/decoders, transceivers and repeaters |
| Surge Protection Equipment | for power, communications, I/O functions and networks |
| I/O functions | sufficient to demonstrate the I/O capability and system normal operation |
| Software | software required for proper operation of the proposed system including application programs and sequences of operation |

C. Factory Test Procedure

1. Test procedures shall define the tests required to ensure that the system meets technical, operational, and performance requirements.
2. The test procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required.
3. Provide for testing all control system capabilities and functions specified and shown.
4. Cover actual equipment and sequences to be used for the specified project and include detailed instructions for test setup, execution, and evaluation of test results.
5. The test reports shall document results of the tests.
6. Surge testing need not be conducted if acceptable documented proof can be provided that such testing has been satisfactorily demonstrated with identical surge protection applied.
7. The procedures shall include the following:

| | |
|--|----------------|
| | Test Procedure |
|--|----------------|

| | |
|--|--|
| Equipment | block diagram |
| hardware and software | descriptions |
| Commands | operator commands |
| I/O functions | test database points with failure modes |
| Passwords | required for each operator access level |
| each type of digital and analog point in the test database | description |
| test equipment | list |
| surge protection | circuit diagrams |
| inputs required (I/O point values and status) and corresponding expected results of each set of input values | for each application program |
| default values | for the application program inputs not implemented or provided for in the contract documents for the application programs to be tested |

- D. Factory Test Report: Submit original copies of data produced during the factory test, including results of each demonstration procedure within 7 days after completion of each test. Arrange the report so that commands, responses, and data acquired are correlated to allow logical interpretation of the data.

Part 3 Execution

3.1 Examination

- A. Verify the following conditions for all equipment not provided by process instrumentation subcontractor, but which interfaces with process control system:
1. Proper installation.
 2. Calibration and adjustment of positioners and transducers.
 3. Correct control action.
 4. Switch settings and dead bands.
 5. Opening and closing speeds and travel stops.
 6. Input and output signals.

3.2 Equipment Installation Requirements

A. Installation

1. Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies.
 - I. Replace factory sealed devices, rather than adjusting.
2. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.
3. Install wiring in exposed areas, including low voltage wiring, in metallic raceways or EMT conduit as specified in [Section 26 05 53 – Raceways and Boxes for Electrical Systems]. Wiring in air plenum areas installed without conduit shall be plenum-rated in accordance with NFPA 70.
4. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each control system using abbreviations, symbols, nomenclature and identifiers as shown; valve schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

B. Isolation, Penetrations and Clearance from Equipment

1. Dielectric isolation shall be provided where dissimilar metals are used for connection and support.
2. Penetrations through and mounting holes in the building exteriors shall be made watertight.
3. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials.
4. Openings shall be sealed with materials which meet the requirements of NFPA 70.
5. Installation shall provide clearance for control-system maintenance.

6. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

C. Device Mounting

1. Devices shall be installed in accordance with manufacturers' recommendations and as shown.
2. Field Mounting: All field mounted instruments which are not self-supporting shall be mounted on 2 inch extra-strong 316 Stainless steel pipe stands.
3. Location and Access: All field mounted instrumentation shall be located near platforms, walkways, etc., to allow easy access for maintenance and adjustments.
4. Clearance at Aisles and Access Ways: Connections shall be made so that instruments or instrument piping do not obstruct aisles or access ways.
5. Local or Field Located Panels: All back-of-panel construction (conduit runs, tubing racks, braces, etc.) shall be installed to avoid interference with future full utilization of panel space and shall be properly supported and installed in a neat and orderly manner.
6. Control devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration.
7. Any deviations shall be documented and submitted to the Engineer for approval prior to mounting.
8. Damaged insulation shall be replaced or repaired after devices are installed to match existing work.
9. Damaged galvanized surfaces shall be repaired by touching up with zinc paint.

D. Instrument Piping and Tubing

1. Tubing System Installation:
 - I. All instrument piping and tubing shall be installed in a neat workmanlike manner, and show no signs of crimping, bends of too short radius, flattening, etc. Extreme care shall be exercised to keep foreign matter out of the system. All open tubing ends and connections shall be kept plugged to keep out dust, dirt, moisture, etc.
 - II. The tubing shall be permanently mounted, supported, and protected in channels.
 - III. Metal tubing supplied in the "Soft-Drawn" conditions or in coils shall be carefully straightened before installation by stretching.

- IV. Each tube shall be tagged, at each end, with its identifying numbers as shown on loop sheets and Drawings. Brady markers, or equal, shall be used for this purpose.
 - V. A valved tee, in accordance with applicable specifications, shall be installed in the signal line from each field mounted pneumatic controller or transmitter for test and calibration of the instrument. Tubing shall be 3/8 inch - 304L SS - 0.035 minimum.
2. Tubing Fittings:
- I. All tubing connections shall be made with compression type fittings. Connections shall be made in strict accordance with manufacturer's recommendations.
 - II. Threads of all fittings shall be wrapped with a single wrap of Teflon tape in place of doping.
 - III. The tubing connection shall not be made prior to completing the make-up of the pipe connection. The tubing shall be checked for correct diameter and wall thickness. The tube ends shall be cut square and deburred. Care shall be taken during cutting to keep the tubing round. Fittings shall not be installed excessively close to a bend. A length of straight tube, not deformed by bending, is required for a proper connection. When a section of bent tubing is being connected, it shall be in proper alignment with the fittings. Springing the tube into position with the fittings will not be permitted. The tubing must be inserted into the fitting until firm contact is made with the seat of the fitting and tightened to manufacturer's specifications.
3. Tubing Supports: Single or double tubing runs shall be supported on 1-1/2 x 3/4 inch aluminum extruded channel. Channels shall be connected together by using flat stainless steel splice plates and stainless steel bolts and nuts. Tubing shall be stretched and laid in the support in neat straight parallel lines. Tubing and cable shall be firmly attached to the support at intervals not exceeding 4 feet. Tubing and cable support shall be sufficiently strong and adequately braced to carry the static load plus a safety margin to allow tubing to be worked in the support. Where supports must be supported from equipment, care shall be taken to prevent vibration and/or expansion from temperature changes. Supports shall be routed so that tubing or cable is accessible and protected from spills or mechanical damage. Support members shall be designed and installed so that they will not become a trough or trap. Vinyl coatings shall be resealed with "Plastisol", or approved equal, after cutting or welding.

Process Connections: Minimum tubing or piping size for process signal lines are to be 1/2 inch. If the instrument connection is different than 1/2 inch, reducing fittings shall be located at the instrument or panel. The first block valve for instrument connection shall be located as close as practicable to the process source. All piping and tubing assemblies shall be cleaned by disconnecting from equipment and blowing out with dry air prior to final assembly.

4. Tubing Tests: Before making final connections to instruments, all lines shall be tested as follows:
 - I. Lines Connecting with Process or Utility Piping: Test at same pressure and length of time as main piping.
 - II. Instrument Air Supply Piping: Test with dry air at 100 psig for 20 minutes.
 - III. Pneumatic Lines: Test in accordance with ISA Standards, RP-71.
 5. After final connections are made to instruments, these joints shall be checked for leaks at the maximum operating pressure of the instrument.
- E. Grooved Mechanical Joints
1. Grooves shall be prepared according to the coupling manufacturer's instructions.
 2. Grooved fittings, couplings, and grooving tools shall be the products of the same manufacturer.
 3. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer.
 4. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded.
- F. Sequences of Operation: Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operate in an optimum manner and fully document changes made.

3.3 Installation of Equipment

- A. Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.
- B. Conduit, Connectors, and Fittings: All conduit, connectors, and fittings shall be in accordance with the requirements of Division 26.
- C. Control Panels: Control panels shall be located as indicated on the drawings. Devices located in the control panels shall be as shown on the drawings or as needed to provide the indicated control sequences. Care shall be taken to prevent damage to the panels by area construction. Panels shall be covered for protection should painting or sand blasting be required in the area.

- D. Instrument Shelters: Instrument shelters shall be installed in the location shown with the bottom 4.0 feet above the supporting surface using legs and secured rigidly to minimize vibrations from winds. Instrument shelters shall be oriented with door facing North. Instruments located in shelters shall be mounted in the 3-dimensional center of the open space of the shelter.
- E. Electric Power Devices:
 - 1. Potential and Current Transformers: Install potential and current transformers in enclosures unless otherwise shown. Current transformer leads shall be shorted when they are not connected to the measurement circuits.
 - 2. Hour Meters: Meters shall be located in the control panel or as otherwise shown. Power to the meter shall be connected to the motor starter auxiliary contacts for pumps, blowers and other motor driven devices. For devices without motor starters, the meter shall be connected in parallel with the load. Where the meter voltage differs from the metered devices voltage, transformer shall be provided as necessary.
 - 3. Current Sensing Relays and Current Transducers for Motors: When used to sense meter/fan/pump status, current sensing relays shall be used for applications under 5 hp. Applications over 5 hp shall use a current transducer.
- F. Output Devices: Output devices (transducers, relays, contactors, or other devices) which are not an integral part of the control panel, shall be mounted in an enclosure mounted adjacent to the control panel, unless otherwise shown. Where H-O-A and/or override switches on the drawings or required by the control sequence, the switches shall be installed so that the control system controls the function through the automatic position and other controls work through the hand position.
- G. Enclosures: All enclosure penetrations shall be from the bottom of the enclosure, and shall be sealed to preclude entry of water using a silicone rubber sealant.
- H. Transformers:
 - 1. Transformers for control voltages below 120 V ac shall be fed from the nearest power panel or motor control center, using circuits provided for the purpose.
 - 2. Provide a disconnect switch on the primary side and a fuse on the secondary side.
 - 3. Transformers shall be enclosed in a steel cabinet with conduit connections.

3.4 Wire, Cable and Connecting Hardware

- A. All wiring shall be in accordance with the requirements of Division 26 and the following.
- B. Metering and Sensor Wiring: Metering and sensor wiring shall be installed in accordance with the requirements of ANSI C12.1, NFPA 70, and Section 26 05 23 – Control Voltage Electrical Power Cables.

- C. Power Line Surge Protection: Control panels shall be protected from power line surges. Protection shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection.
- D. Sensor and Control Wiring Surge Protection:
 - 1. Digital and analog inputs shall be protected against surges induced on control and sensor wiring. Protect digital and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown.
 - 2. Fuses shall not be used for surge protection.
 - 3. Test the inputs and outputs in both the normal and common mode using the following two waveforms:
 - I. The first waveform shall be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes.
 - II. The second waveform shall be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes.
 - 4. Submit certified test results for surge protection.

3.5 Software Installation

- A. Load software required for an operational control system, including databases (for points specified and shown), operational parameters, and system, command, and application programs.
- B. Adjust, tune, debug, and commission all software and parameters for controlled systems to assure proper operation in accordance with the sequences of operation and database tables.

3.6 Control Drawings

- A. Control drawings shall be provided for equipment furnished and for interfaces to equipment at each respective equipment location.
- B. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually shall be prepared in typed form.

3.7 Field Testing and Adjusting Equipment

- A. Provide personnel, equipment, instrumentation, and supplies necessary to perform site testing. The Engineer and Owner will witness the PVT, and written permission shall be obtained from the Engineer before proceeding with the testing.
- B. Original copies of data produced, including results of each test procedure, during PVT shall be turned over to the Owner at the conclusion of each phase of testing prior to Owner approval of the test.

- C. The test procedures shall cover actual equipment and functions specified for the project.
- D. Testing, Adjusting and Commissioning
 1. After successful completion of the factory test as specified, the Contractor will be authorized to proceed with the installation of the system equipment, hardware, and software.
 2. Once the installation has been completed, test, adjust, and commission each control loop and system in accordance with NIST SP 250 and shall verify proper operation of each item in the sequences of operation, including hardware and software.
 3. Calibrate field equipment, including control devices, adjust control parameters and logic (virtual) points including control loop setpoints, gain constants, constraints, and verify data communications before the system is placed online.
 4. Test installed ground rods as specified in IEEE 142 and submit certification stating that the test was performed in accordance with IEEE 142.
 5. Calibrate each instrumentation device connected to the control system control network by making a comparison between the reading at the device and the display at the workstation, using a standard at least twice as accurate as the device to be calibrated.

Check each control point within the control system control network by making a comparison between the control command at the central station and field-controlled device. Deliver trend logs/graphs of all points showing to the Engineer that stable control has been achieved.
 6. Points on common systems shall be trended simultaneously.
 7. Verify operation of systems in the specified failure modes upon Control system network failure or loss of power, and verify that systems return to control system control automatically upon a resumption of control system network operation or return of power.
 8. Deliver a report describing results of functional tests, diagnostics, calibrations and commissioning procedures including written certification to the Owner that the installed complete system has been calibrated, tested, adjusted and commissioned and is ready to begin the PVT. The report shall also include a copy of the approved PVT procedure.
- E. Performance Verification Test (PVT)
 1. Submit test procedures for the PVT.
 2. The test procedure shall describe all tests to be performed and other pertinent information such as specialized test equipment required and the length of the PVT.

3. The test procedures shall explain, in detail, step-by-step actions and the expected results, to demonstrate compliance with all the requirements of the drawings and this specification.
4. The test procedure shall be site specific and based on the inputs and outputs, required calculated points and the sequence of control.
5. Refer to the actions and expected results to demonstrate that the control system performs in accordance with the sequence of control.
6. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.
7. Demonstrate that the completed Control system complies with the contract requirements.
8. All physical and functional requirements of the project including communication requirements shall be demonstrated and shown.
9. Demonstrate that each system operates as required in the sequence of operation.
10. The PVT as specified shall not be started until after receipt of written permission by the Owner, based on the written report including certification of successful completion of testing, adjusting and commissioning as specified, and upon successful completion of training as specified.
11. Upon successful completion of the PVT, furnish test reports and other documentation.

F. Endurance Test

1. Use the endurance test to demonstrate the overall system reliability of the completed system. The endurance test shall be conducted in phases.
2. The endurance test shall not be started until the Engineer notifies the Contractor in writing that the PVT is satisfactorily completed, training as specified has been completed, outstanding deficiencies have been satisfactorily corrected, and that the Contractor has permission to start the endurance test.
3. Provide an operator to man the system 8 hours per day during daytime operations, including weekends and holidays, during Phase I endurance testing, in addition to any Owner's personnel that may be made available.
4. The Owner may terminate testing at any time when the system fails to perform as specified.
5. Upon termination of testing by the Owner or by the Contractor, commence an assessment period as described for Phase II.

6. Upon successful completion of the endurance test, deliver test reports and other documentation, as specified, to the Owner prior to acceptance of the system.
7. Phase I (Testing)
 - I. Each filters operation shall be tested and the system shall operate as specified.
 - II. Make no repairs during this phase of testing unless authorized by the Engineer in writing.
8. Phase II (Assessment)
 - I. After the conclusion of Phase I, identify failures, determine causes of failures, repair failures, and deliver a written report to the Engineer. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed.
 - II. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Engineer and Owner.
 - III. The meeting shall not be scheduled earlier than 5 business days after receipt of the report by the Engineer.
 - IV. As a part of this test review meeting, demonstrate that failures have been corrected by performing appropriate portions of the performance verification test.
 - V. Based on the Contractor's report and the test review meeting, the Owner will determine if retesting is necessary and the restart point.
 - VI. The Owner reserves the right to require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Owner.
 - VII. After the conclusion of any retesting which the Owner may require, the Phase II assessment shall be repeated as if Phase I had just been completed.
9. Exclusions: The Contractor will not be held responsible for failures resulting from the following:
 - I. Outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the control system performed as specified.

- II. Failure of an Owner-furnished communications link, provided that the PLC automatically and correctly operates in the stand-alone mode as specified, and that the failure was not due to Contractor furnished equipment, installation, or software.
- III. Failure of existing equipment, provided that the failure was not due to Contractor furnished equipment, installation, or software.

3.8 Manufacturers' Field Services

- A. Obtain the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified.
- B. The representative shall supervise the installing, adjusting, and testing of the equipment.

END OF SECTION

Part 1 General

1.1 Scope

- A. This Section covers the furnishing of flow instruments and accessories required for the Plant Control System as indicated on the Drawings.
- B. When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1.2 Related Sections

- A. Section 40 60 00 - Process Controls.

1.3 Design Criteria

- A. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.
- B. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service flow conditions indicated below:

| Filter Building | Number | Type | Nominal Size, in | Pipe Service | Avg. Flow, gpm |
|-----------------|--------|---------|------------------|----------------------------|----------------|
| 1949 | 4 | Venturi | 8 | Filtered (Filter Effluent) | 640-1280 |
| 1969 | 4 | Venturi | 12 | Filtered (Filter Effluent) | 704-1408 |

- C. All materials in contact with potable water shall comply with NSF Standard 61.

1.4 Submittals

- A. Submittals shall be made in accordance with Section 01 33 00 and Section 40 60 00.

Part 2 Products

2.1 General

- A. Pressure taps shall incorporate appropriate snubbers.

Venturi Tube

- A. Venturi tube shall be made of cast iron or cast steel. The throat section shall be lined with austenitic stainless steel. Thermal expansion characteristics of the lining shall be the same as that of the throat casting material. The surface of the throat lining shall be machined to a plus or minus 50 mils finish, including the short curvature leading from the converging entrance section into the throat. The metering tube shall be rated for continuous duty service at minimum pressure of 100 psi gage.
- B. ¹ The venturi meter shall be equipped with an inspection port to be located in the meter recovery section. The cover shall be machined of 304 stainless steel and all fastening hardware shall be 304 stainless steel. The cover shall have either an o-ring or gasket seal according to the standard practice of the manufacturer.
- C. ¹ To allow for in-place tap cleaning, one tapset shall be equipped with manual cleanout rods. The rod shaft shall be machined 304 stainless steel designed to be permanently installed in the 0.75" taps. The cleanout rod material shall be stainless steel and an isolation ball valve shall be included in the assembly.
- D. ¹ Manufacturers
 - 1. Equal to Primary Flow Signal, Inc.

Part 3 Execution

3.1 Equipment Installation Requirements

- A. Installation: Install flow meter system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting.
 - 1. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.
- B. Isolation, Penetrations and Clearance from Equipment: Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Installation shall provide clearance for control-system maintenance. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

- C. Device Mounting: Devices shall be installed in accordance with manufacturers' recommendations and as shown. Devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations shall be documented and submitted to the Engineer for approval prior to mounting. Damaged insulation shall be replaced or repaired after devices are installed to match existing work. Damaged galvanized surfaces shall be repaired by touching up with zinc paint.

3.2 Installation of Equipment

- A. Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system
- B. Flow Measuring Devices: Fluid flow instruments shall be installed in accordance with manufacturer's recommendations, unless otherwise indicated in the specification.
 - 1. Venturi Flowmeter: The flowmeter shall be installed with its top above the pipeline in horizontal pipe run installations. The direction of flow shall be upward in vertical pipe run installations. The flowmeter shall be aligned to the direction of the flow and shall be rigidly mounted and vibration free.

END OF SECTION

Part 1 General

1.1 Section Includes

- A. Contractor shall furnish and install complete, with all accessories, analytical instrumentation including for measuring Turbidity.

1.2 Definitions

- A. Definitions, Symbols, and engineering unit abbreviations shall conform to IEEE Standards Dictionary, as applicable.

1.3 Submittals

- A. Submit the following in accordance with Section 01 33 00 - Submittal Procedures:

- B. Action Submittals

- 1. Shop Drawings
- 2. Product Data

- C. Informational Submittals

- 1. Installation Wiring

1.4 Site Environmental Conditions

- A. Location

Latitude 33.04
Longitude -85.03
Altitude 750 ft

- B. Winter Design Temperatures

Outside Air Temperature 32-55 degrees F
Inside Air Temperature 40-70 degrees F

C. Summer Design Temperatures

Outside Air Temperature 60-100 degrees F

Inside Air Temperature 60-80 degrees F

Part 2 Products

2.1 Materials and Equipment

- A. Standard Products: Materials and equipment must be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment shall be products of a single manufacturer. Items of the same type and purpose shall be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Engineer.
- B. Nameplates: Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Laminated plastic nameplates shall be provided for equipment devices and panels furnished. Each nameplate shall identify the device, by tag number. Labels shall be coordinated with the schedules and the process and instrumentation drawings. Laminated plastic shall be 1/8 inch thick, white with black center core. Nameplates shall be a minimum of 1 by 3 inches with minimum 1/4 inch high engraved block lettering. Nameplates for devices smaller than 1 by 3 inches shall be attached by a nonferrous metal chain. All other nameplates shall be attached to the device.

- 2.2 Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.3 Monitoring and Control Parameters

- A. The analytical instrument systems shall be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, and transmitters. Control equipment shall be powered by a 120 v AC, single phase, 60 Hz power source, with local transformers included as needed for signal transmission and subsystem operation. Connecting conductors shall be suitable for installed service. Enclosures shall be rated for NEMA 4.
- B. Universal Digital Transmitter
1. Except where specifically indicated otherwise on the drawings or in these specifications, the transmitter shall be provided with a four digit or analog visual display of the measured parameter and shall provide a 4 to 20 mA DC output signal proportional to the level of the measured parameter. Transmitter shall be located where indicated, mounted integrally with the sensor, wall mounted. The distance between the sensor and transmitter shall not exceed the manufacturer's recommendation. Field preamplifiers and signal conditioners shall be included when necessary to maintain the accuracy from sensor to the programmable logic controller or recorder.

2. Controller shall be Hach SC4500.

C. Liquid Service:

1. Sensors and meters in liquid service shall be rated for continuous duty service at fluid approach velocities from 2.5 ft/s to 5 ft/s with correspondingly higher constriction velocities over a fluid temperature range from 32 degrees F to 80 degrees F at pressures up to 10 psi gage.

2.4 Process Analytical Instrumentation

A. General

1. Probes shall be easily removable without interrupting service. For sensors integral to the electronic controller the sample may be drawn directly into the sensor or may be drawn through a sample tube. For sensors remotely located the sample may be drawn through a sample tube. Sensor and controller construction shall be suitable for operation in the monitored medium.

B. Water Turbidity

1. Low to Mid-Range Turbidity (0-5 NTU)
 - a. System shall be complete and include indicating sensing element and a transmitter/controller. System shall be industrial grade and suitable for measurement of turbidity by direct submersion of the sensing element in a sample chamber for measurement of nephelometric light scatter. Unit shall be designed to comply with USEPA approved methods for regulatory compliance reporting. Sensor assembly shall be suitable for periodic removal for adjustment and cleaning without requiring shutdown of the process.
 - b. Sensor shall be suitable for range from 0 to 5 Nephelometric turbidity units (NTU). The accuracy shall be plus or minus 2 percent of full scale reading, or plus or minus 5.0 mNTU, whichever is greater. Range shall be field verified for the application and adjusted as required.
 - c. Sensing element shall be unaffected by color in the fluid, pressure, and temperature. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration.
 - d. Unit shall be Hach TU5300SC Low Range Laser Turbidimeter with Hach SC4500 controller. One Controller shall be provided for every two turbidimeters.
 - 1) Turbidimeter components to be included:
 - a) Mounting bracket
 - b) Desiccant cartridge

- c) User Manual
- 2) Turbidimeter accessories to be included:
 - a) Automatic Cleaning Module
 - b) Bubble trap
 - c) Turbidimeter maintenance kit
 - d) Glass calibration/verification rod
 - e) StablCal® Sealed Vial Calibration Standards
- 3) Instrument options to be included:
 - a) System Check Module

Part 3 Execution

3.1 Equipment Installation Requirements

A. Installation

1. Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting.
2. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.
3. Install wiring in exposed areas, including low voltage wiring, in metallic raceways or EMT conduit.
4. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Piping and Instrumentation (P&ID) drawings prepared using industry recognized device symbols, clearly defined and describing piping designations to define the service and materials of individual pipe segments and instrument tags employing Instrument Society of America suggested identifiers. Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each control system using abbreviations, symbols, nomenclature and identifiers as shown; and valve schedules.

5. Isolation, Penetrations and Clearance from Equipment: Installation shall provide clearance for control-system maintenance. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.
 6. Device Mounting: Devices shall be installed in accordance with manufacturers' recommendations and as shown. Control devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations shall be documented and submitted to the Owner for approval prior to mounting.
- B. Sequences of Operation: Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operates in an optimum manner and fully document changes made.

3.2 Installation of Equipment

- A. Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.

3.3 Wire, Cable and Connecting Hardware

- A. Sensor Wiring: Sensor wiring shall be installed in accordance with the requirements of ANSI C12.1, NFPA 70.
- B. Power Line Surge Protection: Control panels shall be protected from power line surges. Protection shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection.
- C. Sensor and Control Wiring Surge Protection: Digital and analog inputs shall be protected against surges induced on control and sensor wiring. Protect digital and analog outputs against surges induced on control and sensor wiring. Fuses shall not be used for surge protection. Test the inputs and outputs in both the normal and common mode using the following two waveforms: The first waveform shall be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes. The second waveform shall be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes. Submit certified test results for surge protection.

3.4 Manufacturers' Field Services

- A. Obtain the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment.

3.5 Field Training

- A. Field training oriented to the specific system shall be provided for designated personnel.
- B. Furnish a copy of the training manual for each trainee plus two additional copies. Manuals shall include an agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson.
- C. Furnish audiovisual equipment and other training supplies and materials. Copies of the audiovisuals shall be delivered with the printed training manuals. The Owner reserves the right to videotape training sessions for later use.
- D. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.
- E. Submit the training manual and schedule to receive approval from the Owner at least 30 days before the training.
- F. Maintenance Training:
 - 1. Following the performance test, a minimum period of one training day shall be provided by a factory representative or a qualified Contractor trainer for designated personnel on maintenance of the equipment. The training shall include: physical layout of each piece of hardware, calibration procedures, preventive maintenance procedures, schedules, troubleshooting, diagnostic procedures and repair instructions.

3.6 Operation and Maintenance Data Requirements

- A. Include in the instructions; layout, wiring and control diagrams of the devices as installed, the manufacturer's name, model number, service manual, parts list and a brief description of all equipment and their basic operating features.
- B. List routine maintenance procedures, possible breakdowns and repairs and troubleshooting guides.

END OF SECTION