

CONTRACT PROVISIONS AND PLANS

FOR THE CONSTRUCTION OF:

Salmon Creek Treatment Plant UV System Replacement

VOLUME II – SPECIFICATIONS

Discovery Clean Water Alliance Project No. 93-2023-0048

A Discovery Clean Water Alliance Capital Project with Clark Regional Wastewater
District as Administrative Lead



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February 2026

CONTRACT PROVISIONS AND PLANS

Salmon Creek Treatment Plant UV System Replacement

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Discovery Clean Water Alliance Project No. 93-2023-0048

**FOR INFORMATION REGARDING
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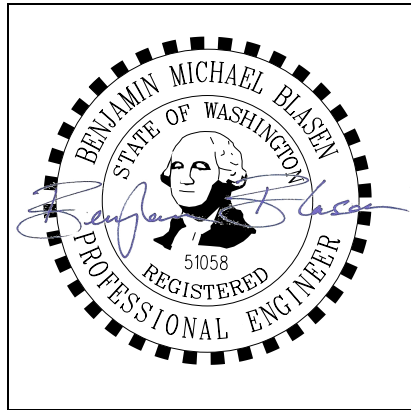
Jennifer Maegan Chang

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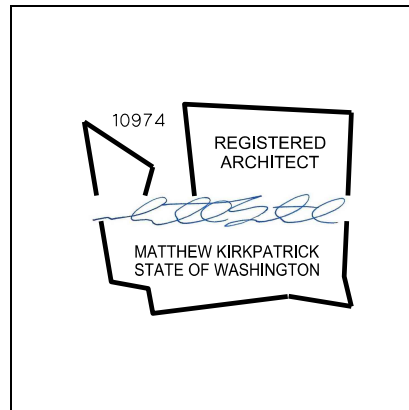
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DIVISION 07 – THERMAL AND MOISTURE PROTECTION



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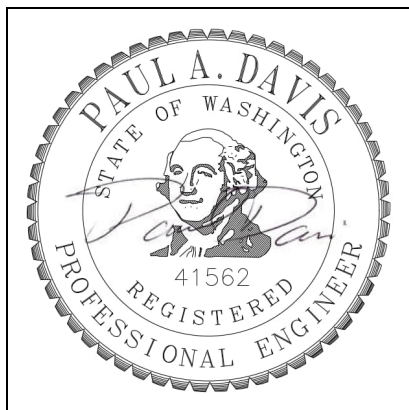
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Ryan Stephen Harbert

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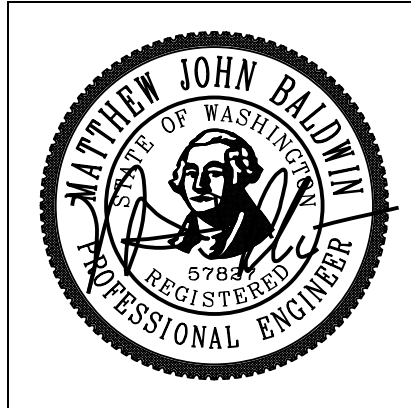
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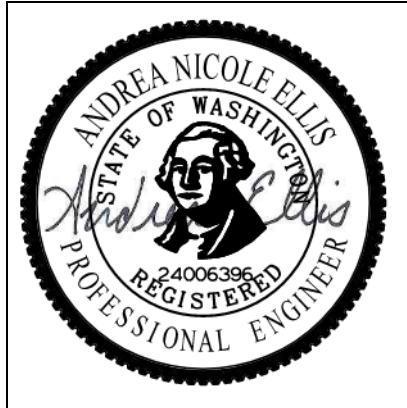
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Andrea Nicole Ellis

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**SECTION 02 41 00
DEMOLITION**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
Guideline K, Containers for Recovered Non-flammable Fluorocarbon
Refrigerants.
 2. American National Standards Institute (ANSI): A10.6, Safety
Requirements for Demolition Operations.
 3. Environmental Protection Agency (EPA), U.S. Code of Federal
Regulations (CFR), Title 40:
 - a. Part 61—National Emission Standards for Hazardous Air
Pollutants.
 - b. Part 82—Protection of Stratospheric Ozone.
 - c. Part 273—Standards for Universal Waste Management.
 4. Occupational Safety and Health Administration (OSHA), U.S. Code of
Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety
and Health Regulations for Construction.

1.02 DEFINITIONS

- A. ACM: Asbestos-containing material.
- B. Demolition: Dismantling, razing, destroying, or wrecking of any fixed
building or structure or any part thereof. Demolition also includes removal of
pipes, manholes tanks, conduit, and other underground facilities, whether as a
separate activity or in conjunction with construction of new facilities.
- C. Modify: Provide all necessary material and labor to modify an existing item to
the condition indicated or specified.
- D. Relocate: Remove, protect, clean, and reinstall equipment, including
electrical, instrumentation, and all ancillary components required to make the
equipment fully functional, to the new location identified on the Drawings.
- E. Renovation: Altering a facility or one or more facility components in any way.

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- F. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste; such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.
- G. Universal Waste Lamp: In accordance with 40 CFR 273, the bulb or tube portion of an electric lighting device, examples of which include, but are not limited to, fluorescent, high-intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps.
- H. Universal Waste Thermostat: A temperature control device that contains metallic mercury in an ampule attached to a bimetal sensing element, and mercury-containing ampules that have been removed from these temperature control devices in compliance with the requirements of 40 CFR 273.

1.03 SUBMITTALS

- A. Informational Submittals:
 - 1. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started.
 - 2. Submit copies of any notifications, authorizations and permits required to perform the Work.
 - 3. Copies of reports and other documentation required for abandoning wells.
 - 4. Submit a shipping receipt or bill of lading for all containers of ozone depleting substance (ODS) shipped.
 - 5. Submit a shipping receipt or bill of lading for all containers of ACM shipped.
 - 6. Submit a shipping receipt or bill of lading for all universal waste shipped.

1.04 EXISTING CONDITIONS

- A. The Engineer is not aware of hazardous materials that will be demolished or removed as part of the Scope of Work.

1.05 REGULATORY AND SAFETY REQUIREMENTS

- A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.

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- B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor's safety requirements shall conform to ANSI A10.6.
- C. Furnish timely notification of this demolition project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.06 DEMOLITION PLAN

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

1.07 SEQUENCING AND SCHEDULING

- A. The Work of this Specification shall not commence until Contractor's Demolition/Renovation Plan has been approved by Engineer.
- B. Include the Work of this Specification in the progress schedule, as specified in Section 01 32 00, Construction Progress Documentation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

- A. Facilities: Portions of facilities and areas scheduled for selective demolition and partial demolition Work are as shown.

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B. Utilities and Related Equipment:

1. Notify Owner or appropriate utilities to turn off affected services at least 48 hours before starting demolition activities.
2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
3. When utility lines are encountered that are not indicated on the Drawings, notify Owner prior to further work in that area.
4. Remove meters and related equipment and deliver to a location as determined by the Owner.
5. Provide a permanent leak-proof closure for water and gas lines.

C. Paving and Slabs:

1. Sawcut concrete and asphaltic concrete paving and slabs as indicated.
2. Provide neat sawcuts at limits of pavement removal as indicated.

D. Roofing:

1. Remove existing canopy system.
2. Provide measures for worker safety during removal of existing materials as specified in Article Regulatory and Safety Requirements. Sequence the Work to minimize hazard to workers.

E. Masonry: Sawcut and remove masonry so as to prevent damage to surfaces to remain and to facilitate the installation of new Work. Where new masonry adjoins existing, the new Work shall abut or tie into the existing construction as indicated.

F. Concrete:

1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished Work, and the remaining concrete is sound.
2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on the Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16 inch. Rebar and small embeds at existing concrete may be required

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to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on the Drawings.

4. At submerged locations not to receive new concrete, paint exposed rebar or metal embed ends with System No. 19a at wastewater surfaces per Section 09 90 00, Painting and Coating.

G. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch, and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include:
 - a. Fill holes and depressions caused by previous physical damage or left as a result of removals in existing concrete walls with an approved patching material, applied in accordance with the manufacturer's printed instructions.

H. Electrical:

1. Where there is no indication on the Drawings to protect or reroute existing conduits, cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4 inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on the Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.
4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.
5. Demolish raceways and cabling not scheduled for reuse.
6. Inaccessibly Concealed: Cut off and abandon in place.
7. Exposed or Concealed Above Accessible Ceilings: Remove.
8. Raceways and Cabling Scheduled for Future Use: Cap/seal and tag.
9. Relocating Equipment: Extend existing wiring or run new wiring from the source.

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10. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
 11. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
 12. Provide new typewritten panelboard circuit directory cards.
- I. Universal Waste Lamps and Thermostats: Manage, contain, package, and label in strict accordance with 40 CFR 273.

3.02 PROTECTION

- A. Refer to Section 01 31 13, Project Coordination, for specific requirements related to concurrent occupancy of facilities to be partially demolished.
- B. Dust and Debris Control:
1. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
 2. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to vehicular traffic.
- C. Traffic Control Signs: Where pedestrian and driver safety is endangered in the area of removal Work, use traffic barricades with flashing lights.
- D. Existing Work:
1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
 2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
 3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
 4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Provide additional structural elements or strengthen existing structural elements to facilitate means and methods used to complete the Work. Work performed under this

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Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.

5. Do not overload pavements to remain.
- E. Weather Protection: For portions of the building scheduled to remain, protect building interior and materials and equipment from weather at all times. Where removal of existing roofing is necessary to accomplish the Work, have materials and workmen ready to provide adequate and temporary covering of exposed areas so as to ensure effectiveness and to prevent loss.
- F. Trees: Protect trees within the Site that might be damaged during demolition and are indicated to be left in place, by a 6-foot-high fence. The fence shall be securely erected a minimum of 5 feet from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the Work shall be replaced in kind, as approved by the Engineer.
- G. 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. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
 3. Protect all facility elements not scheduled for demolition.
 4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.
- H. Protection of Personnel:
 1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
 2. Provide temporary barricades and other forms of protection to protect Owner's personnel and the general public from injury due to demolition Work.
 3. Provide protective measures as required to provide free and safe passage of Owner's personnel and the general public to occupied portions of the structure.

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3.03 BURNING

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

3.04 RELOCATIONS

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

3.05 BACKFILL

- A. Do not use demolition debris as backfill material.
- B. Fill excavations, open basements and other hazardous openings to existing ground level or foundation level of new construction in accordance with Section 31 23 23, Fill and Backfill.

3.06 TITLE TO MATERIALS

- A. All salvaged equipment and materials will remain the property of Owner.
- B. With the exception of the following listed salvaged equipment and materials, all items designated to be removed shall become the property of Contractor:
 - 1. Facility 55 Canopy.
- C. Title to equipment and materials resulting from demolition is vested in the Contractor upon approval by Engineer of Contractor's Demolition/Renovation Plan, and the resulting authorization by Engineer to begin demolition.

3.07 DISPOSITION OF MATERIAL

- A. Do not remove equipment and materials without approval of Contractor's Demolition/Renovation Plan by Engineer.
- B. Remove materials and equipment that are indicated and specified to be removed and relocated by Contractor and deliver to a storage site as directed on the Site.
- C. Remove salvaged items in a manner to prevent damage, and pack or crate to protect the items from damage.

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- D. Repair or replace, at the discretion of Engineer, items damaged during removal or storage.
- E. Deliver salvaged items that are designated as the property of Owner to a storage site as directed on the Site.
- F. Owner will not be responsible for the condition or loss of, or damage to, property scheduled to become Contractor's property after Engineer's authorization to begin demolition. Materials and equipment shall not be viewed by prospective purchasers or sold on the site.

3.08 REUSE OF MATERIALS AND EQUIPMENT

- A. Remove and store materials and equipment listed in Article Title to Materials to be reused or relocated to prevent damage, and reinstall as the Work progresses.
- B. Properly store and maintain equipment and materials in same condition as when removed.
- C. Store equipment and material designated to be reused in a location designated by Owner.
- D. Equipment and material designated to be reused shall be cleaned, serviced, and checked for proper operability before being put back into service.
- E. Engineer will determine condition of equipment and materials prior to removal.

3.09 SPECIALIZED SALVAGE

- A. Ozone Depleting Substances (ODS):
 - 1. Class I and Class II ODS are defined in Section 602(a) and (b), of The Clean Air Act. Prevent discharge of Class I and Class II ODS to the atmosphere. Place recovered ODS in cylinders meeting AHRI Guideline K suitable for the type ODS (filled to no more than 80 percent capacity) and provide appropriate labeling.
 - 2. Dispose of all Class I and Class II ODS refrigerants in accordance with the Clean Air Act Amendment of 1990.
 - 3. Products, equipment, and appliances containing ODS in a sealed, self-contained system (e.g., residential refrigerators and window air conditioners) shall be disposed of in accordance with 40 CFR 82.

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- B. Fire Suppression Containers: Fire suppression system cylinders and canisters with electrical charges or initiators shall be deactivated prior to shipment. Also, safety caps shall be used to cover exposed actuation mechanisms and discharge ports on these special cylinders.

3.10 UNSALVAGEABLE MATERIAL

- A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of following all applicable local, state, and federal laws.
- B. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.11 CLEANUP

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

END OF SECTION

SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
 2. ASTM International (ASTM):
 - a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
 - g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
 - h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - j. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - k. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - l. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
 - m. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
 - n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

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- o. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
- p. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
- q. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
- r. D4259, Standard Practice for Abrading Concrete.
- s. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.02 DEFINITIONS

- A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.
- B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.
- C. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.
- D. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

1.03 SUBMITTALS

- A. Action Submittals: Product data sheets for each material supplied.
- B. Informational Submittals:
 - 1. Repair Mortar System: Manufacturer's preparation and installation instructions.
 - 2. Written description of equipment proposed for concrete removal and surface preparation.
 - 3. Statements of Qualification: Repair mortar system applicator.
 - 4. Field and laboratory test reports.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: For Repair System B, Low-Pressure Spray Mortar, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.
2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.
- B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR

- A. One or two-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.
- B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:
 1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
 2. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
 3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
 4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
 5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
 6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
 7. System shall not produce a vapor barrier.

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8. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
9. Free of chlorides and other chemicals causing corrosion.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 488CI.
2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.
3. Euclid Chemical Co., Cleveland, OH; Tamms Structural Mortar.

2.02 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR

- A. Polymer-modified, one-component or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1 square foot in area or less.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and belowgrade repairs.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco N 300CI.
2. Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.
3. Euclid Chemical Co., Cleveland, OH; DuralTop Gel.

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2.03 WATER

- A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.04 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

- A. Cementitious adhesive, specifically formulated for bonding plastic Portland cement concrete or mortar to hardened Portland cement concrete:
 - 1. Mixed Bonding Agent Properties:
 - a. Pot Life: 75 minutes to 105 minutes.
 - b. Contact Time: 24 hours.
 - 2. Cured Cementitious Adhesive Properties:
 - a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
 - b. Flexural Strength, ASTM C348: 1,000 psi minimum.
 - c. Slant Shear Bond Strength, ASTM C882/C882M at 14 Days:
 - 1) 2-Hour Open Time: 2,500 psi minimum.
 - 2) 24-Hour Open Time: 2,000 psi minimum.
 - 3. Bonding agent shall not produce a vapor barrier.
 - 4. Compatible with and from same manufacturer as the repair system used.
- B. Manufacturers and Products:
 - 1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
 - 2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
 - 3. Euclid Chemical Co., Cleveland, OH: Dural Prep AC.

2.05 EVAPORATION RETARDANT

- A. As specified in Section 03 39 00, Concrete Curing.

2.06 CURING COMPOUND

- A. As specified in Section 03 39 00, Concrete Curing.

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PART 3 EXECUTION

3.01 GENERAL

- A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03 30 00, Cast-in-Place Concrete.

3.02 APPLICATION

- A. General:
 - 1. Repair System B: Medium to large areas and number of repair areas.
 - 2. Repair System C: Small and limited areas and number of repair areas.

3.03 PREPARATION

- A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.
- B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.
 - 1. Use high-pressure abrasive blasting machine as required for Site conditions.
 - 2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
 - 3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.
- C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.
- D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.
- E. Remove unsound concrete to satisfaction of Engineer.

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- F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or feathered edges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge.
- G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:
 - 1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
 - 2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
 - 3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.
- H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.
- I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminants from prepared areas.
- J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer's printed instructions.
- K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

- A. Coat exposed new and existing steel reinforcement and reinforcement mesh with cementitious reinforcement coating at same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

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3.05 PROTECTION

- A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.
- B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used, from low-pressure spray mortar.

3.06 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR PLACEMENT

- A. Mix mortar in accordance with manufacturer's printed instructions.
- B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.
- C. Bonding Agent:
 - 1. Use bonding agent when manufacture required for hand applied areas, in accordance with repair mortar manufacturer's instructions.
 - 2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
 - 3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.
- D. Work mortar firmly and quickly into repair area.
- E. Finish repair mortar to match adjacent concrete surface.
- F. Cure as specified in Article Curing.

3.07 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

- A. Mix mortar in accordance with manufacturer's printed instructions.
- B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.
- C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

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- D. Finish repair mortar to smooth even surface to match adjacent concrete surface.
- E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.08 CURING

- A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.
- B. Cure in accordance with repair mortar manufacturer's printed instructions.
- C. Where permitted by repair mortar manufacturer's printed instructions, commence water or continue water fog curing after repair mortar system application and when curing will not cause erosion of mortar.
- D. Continuously water cure repair mortar system for a period of 7 days.
- E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.
- F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.
- G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.09 FIELD QUALITY CONTROL

- A. Sounding for Hollow Areas:
 - 1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
 - 2. Mark hollow areas for removal and replacement.

3.10 MORTAR REPAIR FAILED TEST

- A. Remove and replace unacceptable Work.
- B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

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- C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.
- D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.
- E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.11 MANUFACTURER'S SERVICES

- A. Provide repair mortar system manufacturer's representative at Site to review acceptability of surface preparation, mixing and installation assistance, training of repair mortar system applicators, inspection, and Certification of Proper Installation.

3.12 CLEANING

- A. Remove overshot low-pressure spray, Repair System B repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

SECTION 03 01 33
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): T277, Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
 2. ASTM International (ASTM):
 - a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
 - g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
 - h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - j. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
 - k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - l. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
 - m. C779/C779M, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
 - n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

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- o. C928/C928M, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs.
- p. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
- q. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
- r. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
- s. D638, Standard Test Method for Tensile Properties of Plastics.
- t. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
- u. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
- v. D4259, Standard Practice for Abrading Concrete.
- w. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.02 DEFINITIONS

- A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.
- B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.
- C. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

1.03 SUBMITTALS

- A. Action Submittals:
 - 1. Product data sheets for each material supplied.
 - 2. The Drawings indicating results of sounding for hollow areas including location, size, estimated quantity, of hollow-sounding areas for each repair location.

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B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Statements of Qualification: Repair mortar system applicator.
4. Field and laboratory test results.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.
- B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR MORTAR SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

- A. One-component or two-component cement-based, flowable, shrinkage compensated repair mortar system.
- B. Compressive Strength, ASTM C109/C109M:
 1. 1 Day: 2,500 psi minimum.
 2. 7 Days: 6,000 psi minimum.
 3. 28 Days: 8,000 psi minimum.
- C. Flexural Strength, ASTM C348 at 28 Days: 770 psi minimum.
- D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10⁶ psi minimum.

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- E. Slant Shear Bond Strength, ASTM C882/C882M Modified:
 - 1. 7 Days: 2,150 psi minimum.
 - 2. 28 Days: 3,000 psi minimum.
 - F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97.0 percent RDM.
 - G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.
 - H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.
 - I. Manufacturers and Products:
 - 1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 466 CI.
 - 2. Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.
- 2.02 REPAIR MORTAR SYSTEM NO. 5—POLYMER MODIFIED REPAIR MORTAR
- A. One-component or two-component, fast-setting, polymer modified cementitious based repair mortar system.
 - B. Compressive Strength, ASTM C109/C109M:
 - 1. 1 Day: 2,500 psi minimum.
 - 2. 7 Days: 5,000 psi minimum.
 - 3. 28 Days: 7,000 psi minimum.
 - C. Flexural Strength, ASTM C348 at 28 Days: 1,500 psi minimum.
 - D. Slant Shear Bond Strength, ASTM C882/C882M Modified at 28 Days: 2,000 psi minimum.
 - E. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
 - F. Abrasion Resistance Depth of Wear, ASTM C779/C779M, Procedure A, at 60 Minutes: 0.033 inch maximum.
 - G. Drying Shrinkage, ASTM C157/C157M Modified, at 28 Days: 0.09 percent maximum.

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H. Rapid Chloride Ion Permeability Based on Charge Passed, ASTM C1202:
28 Days: Under 850 coulombs maximum.

I. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco T 310 CI.
2. Euclid Chemical Co., Cleveland, OH; Duraltop Flowable Mortar.
3. Sika Corp., Lyndhurst, NJ; SikaTop 122 PLUS.

2.03 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.04 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic Portland cement concrete or mortar to hardened Portland cement concrete.

1. Mixed Bonding Agent Properties:
 - a. Pot Life: 75 minutes to 105 minutes.
 - b. Contact Time: 24 hours.
2. Cured Cementitious Adhesive Properties:
 - a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
 - b. Flexural Strength, ASTM C348: 1,000 psi minimum.
 - c. Slant Shear Bond Strength, ASTM C882/C882M:
 - 1) 2-Hour Open Time: 2,500 psi minimum.
 - 2) 24-Hour Open Time: 2,000 psi minimum.
3. Bonding agent shall not produce a vapor barrier.
4. Compatible with, and from same manufacturer as the, repair mortar system used.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH; Dural Prep AC.

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2.05 EPOXY BONDING AGENT

- A. Two-component, moisture insensitive, 100 percent solids epoxy resin.
- B. Tensile Strength, ASTM D638, at 14 Days: 4,400 psi minimum.
- C. Elongation at Break, ASTM D638: 1.49 percent minimum.
- D. Compressive Strength, ASTM D695, at 28 Days for Application Temperature of 73 Degrees F to 77 Degrees F: 8,000 psi minimum.
- E. Bond Strength, ASTM C882/C882M, at 14 Days: 1,800 psi minimum.
- F. Pot Life, at 73 Degrees F to 77 Degrees F: 75 minutes minimum.
- G. Manufacturers and Products: BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; MasterEmaco ADH 326 when ambient temperature is 73 degrees F or higher.

2.06 EVAPORATION RETARDANT

- A. As specified in Section 03 39 00, Concrete Curing.

2.07 CURING COMPOUND

- A. As specified in Section 03 39 00, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

- A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system.

3.02 APPLICATION

- A. General:
 - 1. Repair Mortar System No. 3: Patches, joints, or overlays 1 inch thick or greater. Return to service in 7 days or more.
 - 2. Repair Mortar System No. 5:
 - a. Patches and Overlays: 1/4 inch to 3 inches thick.
 - b. Return to service for foot traffic in 4 hours; wheel traffic in 7 days.
 - c. Working Time: 30 minutes at 70 degrees F.
 - d. Application Temperature Range: 45 degrees F to 90 degrees F.

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3.03 PREPARATION

- A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer. Review proposed extent of repair with Engineer.
- B. Remove unsound, deteriorated, or otherwise defective areas of concrete from Work areas.
 - 1. Remove concrete to abrade substrate concrete surface to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
 - 2. Where final surface is required to be flush with existing adjacent surface, remove existing concrete depth as required for application of minimum thickness of repair mortar.
- C. Do not use power-driven jackhammers, chipping hammers, scabblers, or scarifiers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.
- D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.
- E. Remove unsound concrete to satisfaction of Engineer.
- F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge.
- G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to entire circumference of exposed steel reinforcement if one or more of the following surface conditions exist:
 - 1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
 - 2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.

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3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.
- H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.
- I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminants from prepared areas.
- J. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System No. 3, and No. 5: Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer's printed instructions.
- K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

- A. Coat exposed new and existing steel reinforcement with cementitious reinforcement coating at the same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

3.05 PROTECTION

- A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.
- B. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

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3.06 PLACEMENT

A. Repair Mortar System No. 3 and No. 5:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.
7. Repair Mortar System No. 5 screed or use self-leveling mixture to obtain a uniform and plane surface.

3.07 FINISHING

- A. Spray full strength evaporation retardant on fresh concrete to prevent rapid drying during hot and windy weather.

3.08 CURING

- A. Apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.09 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Chain drag or light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

3.10 MORTAR REPAIR FAILED TEST

- A. Remove and replace unacceptable Work.
- B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge, remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

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- C. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.11 MANUFACTURERS' SERVICES

- A. Provide mortar manufacturer's representative at Site to advice on product selection, review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.12 CLEANING

- A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

END OF SECTION

SECTION 03 10 00
CONCRETE FORMING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Concrete Institute (ACI):
 - a. 117, Specification for Tolerances for Concrete Construction and Materials.
 - b. 350, Code Requirements for Environmental Engineering Concrete Structures.
 - c. 350.5, Specifications for Environmental Concrete Structures.

1.02 DEFINITIONS

- A. Defective Areas: See definition in Section 03 30 00, Cast-in-Place Concrete.
- B. Exposed Concrete: See definition in Section 03 30 00, Cast-in-Place Concrete.

1.03 DESIGN REQUIREMENTS

- A. Design formwork in accordance with ACI 350.5 and ACI 350 to provide concrete finishes specified in Section 03 30 00, Cast-in-Place Concrete.
- B. Unless otherwise specified, limit deflection of facing materials for concrete surfaces to comply with ACI 350.5. Limit deflection of facing materials to comply with tolerance limits established by Contract Documents and with tolerances required by equipment manufacturers. Coordinate tolerance requirements with equipment manufacturers.
- C. Form liner and concrete mixtures shall be compatible. Coordinate compatibility between form liner manufacturer and concrete producer.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings:
 - a. Formwork drawings signed and sealed by a licensed professional engineer in the state of the Project.
 - b. Layout of panel joints, form liners, and tie hole pattern.

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2. Product Data:
 - a. Form release agent.
 - b. Form ties.
 - c. Products to be used for sealing tie holes.
 - d. Manufacturer's data for form liners.
3. Samples:
 - a. One each as follows:
 - 1) Form liners.

B. Informational Submittals:

1. Statement of qualifications for formwork designer.
2. Statement of qualifications for form liner designer.
3. Statement of qualifications for form liner installer.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Formwork Designer: Formwork, falsework, and shoring design shall be designed by an engineer licensed in the state of Project.
2. Form liner designer shall have previous experience with design and installation of comparable form liners.
3. Form liner installer shall be approved by form liner manufacturer.

PART 2 PRODUCTS

2.01 FORM MATERIALS

A. Wall Forms:

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.
2. Where steel forms are used, treat steel surfaces to prevent rusting using products approved for use on steel forms.

B. Form Liners:

1. Material: Elastomeric, FRP, ABS, or PVC.
2. Manufacturing Tolerance: Overall dimensions within 0.125 inch at time of manufacture.

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- C. Painted Surface Forms: High-density overlay plywood for flat concrete surfaces to be painted.
- D. All Other Forms: Materials as specified for wall forms.

2.02 ACCESSORIES

- A. Form Release Agent:
 - 1. Material:
 - a. Shall not bond with, stain, or adversely affect concrete surfaces.
 - b. Shall not impair subsequent treatments of concrete surfaces when applied to forms.
 - c. Ready-to-use water-based material formulated to reduce or eliminate surface imperfections.
 - d. Contain no mineral oil or organic solvents.
 - 2. Manufacturers and Products: Not for surfaces exposed to potable water.
 - a. BASF, Shakopee, MN; MBT MasterFinish RL 211.
 - b. Cresset Chemical Company; Crete-Lease 20-VOC-Xtra.
- B. 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.
- C. Form Snap-Ties:
 - 1. Material: Steel.
 - 2. Spreader Inserts:
 - a. Conical or spherical type.
 - b. Design to maintain positive contact with forming material.
 - c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
 - 3. Wire ties not permitted.
 - 4. Flat bar ties for panel forms; furnish plastic or rubber inserts with minimum 1.5-inch depth and sufficient dimensions to permit patching of tie hole.
- D. Form Snap-Ties with Water Stop:
 - 1. For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
 - a. Integral steel water stop 0.103-inch thick and 0.625-inch diameter tightly and continuously welded to tie.

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- b. Neoprene water stop 3/16-inch thick and 15/16-inch diameter whose center hole is one-half diameter of tie, or molded plastic water stop of comparable size.
 - c. Orient water stop perpendicular to tie and symmetrical about center of tie.
 - d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.
- E. Through-Bolts:
 - 1. At Contractor's option, may be used as alternate to form snap-tie or form snap-tie with water stop.
 - 2. Tapered minimum 1-inch diameter at smallest end.
 - 3. Elastic Vinyl Plug for Through-Bolt Tie Holes:
 - a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal; forms watertight seal.
 - b. Manufacturers and Products:
 - 1) Dayton Superior, Miamisburg, OH; A58 Sure Plug.
 - 2) Greenstreak Group, Inc., St Louis, MO; X-Plug.

PART 3 EXECUTION

3.01 FORM SURFACE PREPARATION

- A. Prior to coating surface, 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.
- B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by manufacturer.
- C. Steel Forms: Apply form release agent as soon as they are cleaned to prevent discoloration of concrete from rust.
- D. Form Liner Forms:
 - 1. Prepare forms as recommended by manufacturer.
 - 2. Provide liners in full sheets and locate seams as horizontal and vertical grooves.
 - 3. Anchor liners to formwork as recommended by liner manufacturer.
 - 4. Clean form liner after each use and do not use only form release agents on formwork.

3.02 ERECTION

- A. General: In accordance with ACI 301, unless otherwise specified.
- B. Beveled Edges (Chamfer):
 - 1. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
 - 2. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain Engineer's approval of size prior to placement of beveled edge.
- C. Wall Forms:
 - 1. Do not reuse forms with damaged surfaces.
 - 2. Locate form ties and joints in uninterrupted uniform pattern.
 - 3. Inspect form surfaces prior to installation to ensure conformance with specified tolerances.
- D. Forms Supporting Form Liners:
 - 1. Construct to structurally withstand deflection, movement, leakage, high hydraulic pressures resulting from rapid filling and heavy-high frequency vibration.
 - 2. Lay out form joints and ties in uniform pattern, unless otherwise shown.
- E. Form Tolerances:
 - 1. Provide forms in accordance with ACI 117 and ACI 318, and the following tolerances for finishes specified:
 - a. See the Schedule of Concrete Finishes in Section 03 30 00, Cast-in-Place Concrete, for beam, column, and wall types related to required form tolerances.
 - b. Wall Tolerances:
 - 1) Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
 - 2) Wall Type W-A:
 - a) Plumb within 1/4 inch in 10 feet or within 1 inch from top to bottom for walls over 40 feet high.
 - b) Depressions in Wall Surface: Maximum 5/16 inch when 10-foot straightedge is placed on high points in all directions.

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- 3) Wall Type W-B:
 - a) Plumb within 1/8 inch in 10 feet or within 1/2 inch from top to bottom for walls over 40 feet high.
 - b) Depressions in Wall Surface: Maximum 1/8 inch when 10-foot straightedge is placed on high points in all directions.
- 4) Thickness: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
- 5) Form Offset: Between adjacent pieces of formwork, facing material shall not exceed 1/4 inch.

3.03 FORM REMOVAL

- A. Nonsupporting forms, sides of beams, walls, columns, and similar parts of Work, may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
 1. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
 2. Curing and protection operations are maintained.
- B. Elevated Structural Slabs or Beams: In accordance with ACI 318, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28-day compressive strength as determined by test cylinders.
- C. Form Ties: Remove conical inserts or through bolts and plug holes as specified in Section 03 30 00, Cast-in-Place Concrete.

3.04 MANUFACTURER'S SERVICES

- A. Provide form liner manufacturer's representative at Site for installation assistance, and inspection.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

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

END OF SECTION

SECTION 03 15 00
CONCRETE JOINTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. A36/A36M, Specification for Carbon Structural Steel.
 - b. A615/A615M, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - d. A767/A767M, Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - e. C920, Specification for Elastomeric Joint Sealants.
 - f. D226, Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 - g. D227, Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
 - h. D994, Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
 - i. D1056, Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
 - j. D1171, Standard Guide for Evaluating Nonwoven Fabrics.
 - k. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
 - l. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
 - m. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
2. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.

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1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Waterstop: Details of splices, method of securing and supporting waterstop in forms to maintain proper orientation and location during concrete placement.
 - b. Construction Joints, Expansion Joints, and Control Joints: Layout and location for each type. Include joint locations shown on Drawings, additional required joint locations, and any proposed alternate locations.
2. Product Data:
 - a. Waterstops.
 - b. Bond breaker.
 - c. Premolded joint fillers.
 - d. Pourable joint fillers.
 - e. Preformed control joints.
 - f. Epoxy-coated dowels.
 - g. Roofing felt.
 - h. Accessories not specified in other sections.
3. Samples: PVC waterstop splice, joint, and fabricated cross of each size, shape, and fitting of waterstop.

B. Informational Submittals:

1. Certification:
 - a. Letter stating compatibility between liquids being contained and materials used for:
 - 1) Waterstops.
 - 2) Joint fillers.
 - b. Manufacturer's application instructions for:
 - 1) Bonding agent.
 - 2) Bond breaker.
2. Manufacturer's written instructions for product shipment, storage, handling, installation/application, and repair for:
 - a. Waterstops.
 - b. Bond breaker.
 - c. Bonding agent.
 - d. Premolded joint fillers.
 - e. Pourable joint fillers (sealant proportions not required as products used only as a filler).
 - f. Preformed control joints.

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1.03 DELIVERY, STORAGE, AND HANDLING

- A. Acceptance at Site: Verify delivered materials are in accordance with Specifications, regulatory agencies, and Manufacturer's product data sheets prior to unloading and storing onsite.
- B. Storage: Store materials under tarps to protect from oil, dirt, and sunlight or as required by Manufacturer.

PART 2 PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) WATERSTOP

- A. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.
- B. Specific Gravity: Approximately 1.37.
- C. Shore Durometer Type A Hardness: Approximately 80.
- D. Performance Requirements: COE Specification CRD-C-572.
- E. Type Required in Expansion Joints: Where waterstop is indicated on the Drawings, provide 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center.
- F. Type Required in Contraction and Control Joints: Where waterstop is indicated on the Drawings, provide 6 inches wide or 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center.
- G. Type Required in Construction Joints: Where waterstop is indicated on the Drawings, provide flat ribbed, 6 inches wide or 9 inches wide with parallel longitudinal ribs or protrusions on each side of strip center. Center bulb is optional.
- H. Corrugated or tapered type waterstops are not acceptable.
- I. Thickness: Constant from bulb edge (or center of waterstop) to outside stop edge.
- J. Minimum Weight per Foot of Waterstop:
 - 1. 1.60 pounds for 3/8 inch by 6 inches.
 - 2. 2.30 pounds for 3/8 inch by 9 inches.

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- K. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.
- L. Manufacturers and Products for Center Bulb Type:
 - 1. Use same manufacturers for flat ribbed profile:
 - a. Vinylex Corp., St. Louis, MO; No. RB638H (6 inches by 3/8 inch) and No. RB938H (9 inches by 3/8 inch).
 - b. Sika Corporation, Lyndhurst, NJ; Style 732 (6 inches by 3/8 inch) and Style 735 (9 inches by 3/8 inch).
 - c. Durajoint, Garrettsville, OH; Type 9 (6 inches by 3/8 inch), and Type 10 (9 inches by 3/8 inch).
 - d. JP Specialties, Inc., Murrieta, CA; PVC638 (6 inches by 3/8 inch ribbed center bulb), and PVC938 (9 inches by 3/8 inch).
 - e. BoMetals, Carrollton, GA; No. RCB-638LB (6 inches by 3/8 inch) and No. RCB-938NT (9 inches by 3/8 inch).
 - f. Dacon Plastics LLC, Jacksonville, TX; No. RCB17 (6 inches by 3/8 inch) and No. RCB18 (9 inches by 3/8 inch).

2.02 HYDROPHILIC WATERSTOP

- A. For use at construction joints only, where new concrete is placed against existing concrete and as shown on the Drawings.
- B. Material shall be a nonbentonite hydrophilic rubber compound.
- C. Manufacturers and Products:
 - 1. Sika Corporation, Lyndhurst, NJ; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
 - 2. Adeka Ultra Seal, OCM Inc., Grayslake, IL; MC-2010M with 3M-2141 adhesive and P-201 sealant.
 - 3. JP Specialties, Inc., Murrieta, CA; Type NB190 Profile A with Type NB190 Waterstop Paste and NB 190 Waterstop Adhesive sealant.

2.03 INJECTION-TYPE WATERSTOP

- A. Re-injectable waterstop hose system for use where shown on the Drawings.
- B. Re-injectable Water Stop Hose:
 - 1. Contain discharge openings to allow for disbursement of an injection material into expansion joint.
 - 2. Discharge openings designed to be sealed tight during concreting operation to prevent entry of mixing water and cement slurry.

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3. Allows free and uniform discharge of injection material over entire length of hose during injection process.
 4. Able to be internally cleaned by using water and vacuum pressure.
- C. Injection Material: Hydrophilic or hydrophobic resin grout for use in expansion joints as recommended by re-injectable waterstop hose manufacturer.
- D. Manufacturers and Products:
1. Sika, Lyndhurst, NJ; SikaFuko VT Injection Hose System with Sika Inject 306.
 2. GCP Applied Technologies, Cambridge, MA; TRIOject Injection Hose System with Hydro Active Grout.

2.04 RETROFIT PVC WATERSTOP

- A. Material: See Article Polyvinyl Chloride (PVC) Waterstop.
- B. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.
- C. Stainless Steel Batten Bar: AISI Type 304. Size and configuration in accordance with manufacturer's instructions.
- D. Manufacturers and Products:
1. Vinylex Corp., St Louis, MO; No. RET638 (6 inches by 3/8 inch) and No. RET912 (9 inches by 3/8 inch).
 2. Greenstreak, St. Louis, MO; Style 609 (6 inches by 3/8 inch) and Style 667 (9 inches by 1/2 inch).
 3. BoMetals, Carrollton, GA; No. RF-912 (9 inches by 1/2 inch).

2.05 BOND BREAKER

- A. Tape for Joints: Adhesive-backed glazed butyl or polyethylene tape. Same width as joint that will adhere to premolded joint material or concrete surface.
- B. Use bond prevention material as specified in Section 03 30 00, Cast-in-Place Concrete, except where bond breaker tape is specifically called for on the Drawings.

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2.06 PREMOLDED JOINT FILLER

- A. Bituminous Type: ASTM D994 or ASTM D1751.
- B. Sponge Rubber:
 - 1. Neoprene, closed cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 kPa to 168 kPa (17 psi to 24 psi) minimum. Use in joints for potable and nonpotable water containment structures.
 - 2. Manufacturer and Product: Monmouth Rubber and Plastics, Corp, Long Branch, NJ; Durafoam DK5151.

2.07 STEEL EXPANSION JOINT DOWELS

- A. Dowels: ASTM A36/A36M round smooth steel bars.
- B. Bar Coating: As specified in Section 09 90 00, Painting and Coating, with factory-applied epoxy coating and factory or field applied lubrication coating.

2.08 ACCESSORIES

- A. Roofing Felt: ASTM D226, Type II, 30-pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.
- B. Steel Reinforcement: As specified in Section 03 21 00, Steel Reinforcement.
- C. Nails: Galvanized, as required for securing premolded joint filler.
- D. Galvanized Rebar at Control Joints: ASTM A767/A767M and ASTM A615/A615M Grade 60 prior to galvanizing.
- E. Ties for PVC Waterstop: "Hog Rings" or grommets for each edge at 12-inch maximum spacing.

PART 3 EXECUTION

3.01 GENERAL

- A. Commence concrete placement after joint preparation is complete.
- B. Time Between Concrete Pours: As specified in Section 03 30 00, Cast-in-Place Concrete.

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3.02 SURFACE PREPARATION

- A. Construction Joints: Clean concrete surface prior to placement of abutting concrete.
 - 1. Remove laitance and spillage from steel reinforcement and dowels.
 - 2. Roughen surface to minimum of 1/4-inch amplitude:
 - a. Sandblast after concrete has fully cured.
 - b. Water blast after concrete has partially cured.
 - c. Green cut fresh concrete with high-pressure water and hand tools.
 - 3. If present in joint, do not damage waterstop.
- B. Expansion Joint:
 - 1. Use wire brush or motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic waterstop to top of joint.
 - 2. Use dry, high-pressure air to remove dust and foreign material, and dry joint.
 - 3. Prime surfaces as required before placing joint filler.
 - 4. If present in joint, do not damage waterstop.
- C. Contraction Joint:
 - 1. Coat concrete surfaces above and below plastic waterstop with bond breaker.
 - 2. If present in joint, do not damage or coat waterstop.
- D. Construction Joint with Hydrophilic Waterstop:
 - 1. Follow hydrophilic waterstop manufacturer's written instructions.
 - 2. Concrete surface along which waterstop will be installed must be smooth, clean, and dry. Grind concrete as required.
 - 3. Clean debris, dirt, dust, and foreign material from concrete and waterstop surfaces.

3.03 INSTALLATION OF WATERSTOPS

- A. General:
 - 1. Continuous waterstop shall be installed in all construction joints in walls and slabs of liquid-containing basins and channels and in walls of belowgrade structures, unless specifically noted otherwise.
 - 2. Join waterstop at intersections to provide continuous seal.
 - 3. Center waterstop on joint.

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4. Secure waterstop in correct position. Tie waterstop to steel reinforcement using grommets, "Hog Rings," or tiewire at maximum spacing of 12 inches. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.
7. Joints in Footings and Slabs:
 - a. Ensure that space beneath horizontal waterstop is completely filled with concrete.
 - b. During concrete placement, make visual inspection of waterstop area.
 - c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift ribbed waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.

B. Plastic (PVC) Waterstops:

1. Install in accordance with manufacturer's written instructions.
2. Splice in accordance with waterstop manufacturer's written instructions using Teflon-coated thermostatically controlled heating iron at approximately 380 degrees F.
 - a. Allow at least 10 minutes before new splice is pulled or strained in any way.
 - b. Finished splices shall provide cross section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
 - c. Use only factory made waterstop fabrications for all intersections, changes of directions and transitions.
 - d. Field splice permitted only for straight butt welds.
 - e. Edge welding not permitted.
 - f. Additional splicing defects which are unacceptable and are cause for rejection:
 - 1) Misalignment of center bulbs and ribs greater than 1/16 inch or where waterstop cross-section is reduced by more than 15 percent.
 - 2) Charred or burnt material.
3. Wire looped plastic waterstop may be substituted for plastic waterstop.

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C. Hydrophilic Waterstop:

1. Install in accordance with manufacturer's written instructions.
2. Provide minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of steel reinforcement, locate centered between layers of steel or as shown.
3. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
4. Lap ends of waterstop strip together at splices and corners and join with sealant.
5. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.
6. Lap hydrophilic waterstop 2 feet minimum with intersecting plastic waterstops.

D. Injection-Type Waterstop:

1. Install re-injectable waterstop hose in accordance with manufacturer's instructions.
2. After concrete has been placed and cured for a minimum of 28 days, inject specified injection material into re-injectable waterstop hose in accordance with manufacturer's instructions.
3. Upon completion of injection process, clean out remaining injection material in hose in accordance with manufacturer's instructions to allow for future injections.

E. Retrofit PVC Waterstop:

1. Install retrofit PVC waterstop in accordance with manufacturer's instructions.
2. Prepare surface of existing concrete in accordance with manufacturer's instructions. Apply a bed of epoxy, approximately 1/8 inch thick and slightly wider than waterstop base, to concrete surface.
3. Place the retrofit waterstop in place prior to the curing of the epoxy, securing waterstop with stainless steel batten bars and stainless steel post-installed anchors. Fasten one side at a time, making sure retrofit profile is positioned to eliminate any air pockets or voids between waterstop and existing concrete.
4. Butt splice by thermally fusing the free ends together prior to attaching to wall in accordance with manufacturer's instructions.

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3.04 EXPANSION JOINT INSTALLATION

A. Premolded Joint Filler:

1. Sufficient in width to completely fill joint space where shown.
2. Install per manufacturer's written instructions.
3. If waterstop is in joint, cut premolded joint filler to butt tightly against waterstop and concrete face.
4. Precut premolded joint filler to required depth at locations where joint filler or sealant is to be applied.
5. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately shaped material. Entire joint above waterstop, in slabs, shall be formed and removed so that entire space down to waterstop can be filled with the pourable joint filler.
6. Vibrate concrete thoroughly along joint form to produce dense, smooth surface.

B. Bituminous Type Premolded Joint Filler:

1. Drive nails approximately 1 foot 6 inches on center through filler, prior to installing, to provide anchorage embedment into concrete during concrete placement.
2. Secure premolded joint filler in forms before concrete is placed.
3. Install in walkways, at changes in direction, at intersections, at each side of driveway entrances, and at 45-foot intervals, maximum.

C. Sponge Rubber Joint Filler: Install per manufacturer's written instructions.

D. Steel Expansion Joint Dowels:

1. Install coated and lubricated bars parallel to wall or slab surface and in true horizontal position perpendicular to joint in both plan and section view, to permit joint to expand or contract without bending dowels.
2. Secure dowels tightly in forms with rigid ties.
3. Install steel reinforcement in concrete as shown.

3.05 CONTRACTION JOINT INSTALLATION

A. Place bond breaker above and below waterstop.

B. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.

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3.06 CONTROL JOINT INSTALLATION

- A. Locate galvanized or epoxy-coated steel reinforcement as shown.
- B. Install waterstop.
- C. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.
- D. Install bond breaker to concrete surfaces above and below waterstop.

3.07 PREFORMED CONTROL JOINTS

- A. Use only where specifically shown; do not use in water-holding basins.
- B. Locate slightly below top of slab.
- C. Install in accordance with manufacturer's written instructions in straight, full-length pieces.
- D. Steel Strip Type with Preformed Groove: Brace to withstand pressure of concrete during and after placement using only approved stakes and other secondary installation materials.

3.08 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

3.09 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

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

END OF SECTION

SECTION 03 21 00
STEEL REINFORCEMENT

PART 1 GENERAL

1.01 GENERAL

- A. Steel reinforcement shall comply with ACI 301 and as modified in the following.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI):
 - a. 117, Specification for Tolerances for Concrete Construction and Materials.
 - b. 301, Specifications for Structural Concrete.
 - c. SP-66, Detailing Manual.
 2. American Welding Society (AWS): D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
 3. ASTM International (ASTM):
 - a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - b. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - c. A767/767M, Standard Specification for Zinc-Coated (Galvanized) Steel bars for Concrete Reinforcement.
 - d. A1064/A1064M, Standard Specification for Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 4. Concrete Reinforcing Steel Institute (CRSI):
 - a. Placing Reinforcing Bars.
 - b. Manual of Standard Practice.
 5. International Code Council (ICC): Evaluation Services Report.

1.03 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings prepared in accordance with ACI 301 and ACI SP-66:
 - a. Bending lists.
 - b. Placing Drawings.
 2. Welded, metallic sleeve splice, and mechanical threaded connection.

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B. Informational Submittals:

1. Lab test reports for steel reinforcement showing stress-strain curves and ultimate strengths.
2. Mechanical Threaded Connections:
 - a. Current ICC Evaluation Services Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
 - b. Verification device threads have been tested and meet requirements for thread quality, in accordance with manufacturer's published methods.
 - c. Manufacturer's instructions.
3. Welding Qualification: Prior to welding, submit welder qualifications and nondestructive testing procedures in accordance with Section 05 05 23, Welding.
4. Test results of field testing.

1.04 QUALITY ASSURANCE

- A. Welder Qualifications: Certified in accordance with AWS D1.4/D1.4M.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with ACI 301 and recommendations of CRSI Placing Reinforcing Bars.

PART 2 PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars:

1. Includes stirrups, ties, and spirals.
2. ASTM A615/A615M, Grade 60, where welding is not required.
3. ASTM A706/A706M, Grade 60, for reinforcing to be welded.
4. ASTM A767/767M, Grade 60, for galvanized bars.

B. Mechanical Splices and Connections:

1. Metal Sleeve Splice:
 - a. Furnish with cast filler metal, capable of developing, in tension or compression, 125 percent of minimum tensile strength of bar.
 - b. Manufacturer and Product: Erico Products, Inc., Cleveland, OH; Cadweld T-Series.

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2. Mechanical Threaded Connections:
 - a. Furnish metal coupling sleeve with internal threads engaging threaded ends of bars developing in tension or compression 125 percent of yield strength of bar.
 - b. Manufacturers and Products:
 - 1) Erico Products, Inc., Cleveland, OH; Lenton Reinforcing Steel Couplers.
 - 2) Erico Products, Inc., Cleveland, OH; Lenton Lock Mechanical Rebar Splicing System.
 - 3) Richmond Screw Anchor Co., Inc., Fort Worth, TX; Richmond DB-SAE Dowel Bar Splicers.

C. Welded Wire Fabric:

1. ASTM A1064, using wire of 75 ksi minimum tensile strength.
2. Furnish flat sheets only, rolled sheets not permitted.

2.02 ACCESSORIES

A. Bar Supports and Spacers:

1. Use precast concrete bar supports and side form spacers, unless noted otherwise. Do not use other types of supports or spacers.
2. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.
3. Use only precast concrete bar supports where concrete surfaces are exposed to weather, earth, water, chloride intrusion, or corrosive chemicals. Bar supports shall be nonconductive and have geometry and bond characteristics that deter movement of moisture from the surface to the reinforcement.
4. Precast concrete supports shall have same minimum strength and shall be made from same materials as that of the concrete in which they are to be embedded. Precast concrete supports shall be cast and properly cured for at least 7 days before use and shall have a wire or other device cast into each block for the purpose of attaching them securely to steel reinforcement.
5. In Beams, Columns, Walls, and Slabs Exposed to View after Form Removal: Use small precast concrete blocks made of same color as concrete in which they are embedded.
6. Design and fabricate special bar supports for top reinforcing bars in slabs where standard bar supports do not possess necessary geometry, strength, or stiffness.

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7. Precast Concrete Supports: Total bond precast, high-performance concrete bar supports as supplied by Dayton Superior, Miamisburg, OH, Dobies.

PART 3 EXECUTION

3.01 PREPARATION

- A. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.
- B. Clean reinforcing bars of loose mill scale, oil, earth, and other contaminants.

3.02 INSTALLATION

- A. Bundle or space bars, instead of field bending where construction access through reinforcing is necessary.
- B. Splicing:
 1. Minimum length of lap splices shall comply with table in Contract Documents.
 2. Use lap splices, unless otherwise shown or permitted in writing by Engineer.
 3. Welded Splices: Accomplish by full penetration groove welds and develop a minimum of 125 percent of yield strength of bar.
 4. Stagger splices in adjacent bars where indicated.
- C. Mechanical Splices and Connections:
 1. Use only in areas specifically approved in writing by Engineer.
 2. Install threaded rods as recommended by manufacturer with threads totally engaged into coupling sleeve and in accordance with ICC Evaluation Services Report or equivalent code agency report.
 3. For metal sleeve splice, follow manufacturer's installation recommendations.
 4. Maintain minimum edge distance and concrete cover.
- D. Tying Reinforcing Bars:
 1. Tie every other intersection on mats made up of No. 3, No. 4, No. 5, and No. 6 bars to hold them firmly at required spacing.
 2. Bend tie wire away from concrete surface to provide clearance of 1 inch from surface of concrete to tie wire.

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- E. Reinforcement Around Openings: On each side and above and below pipe or opening, place an equivalent area of steel bars to replace steel bars cut for opening. Extend steel reinforcing a standard lap length beyond opening at each end.
- F. Welding Reinforcement:
 - 1. Only ASTM A706/A706M bars may be welded.
 - 2. Do not perform welding until welder qualifications are approved.
- G. Straightening and Rebending: Field bending of steel reinforcement bars is not permitted.
- H. Unless permitted by Engineer, do not cut reinforcing bars in field.

3.03 WELDED WIRE FABRIC INSTALLATION

- A. Use only where specifically shown.
- B. Extend fabric to within 2 inches of edges of slab and lap splices at least 1-1/2 courses of fabric or minimum 8 inches.
- C. Tie laps and splices securely at ends and at least every 24 inches with tie wire.
- D. Place welded wire fabric on concrete blocks and rigidly support equal to that provided for reinforced bars. Do not use broken concrete, brick, or stone.
- E. Do not use fabric that has been rolled. Install flat sheets only.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

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

END OF SECTION

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 REFERENCES

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

1. American Concrete Institute (ACI):
 - a. 117, Specification for Tolerances for Concrete Construction and Materials.
 - b. 301, Specifications for Structural Concrete.
 - c. 305.1, Specification for Hot Weather Concreting.
 - d. 306.1, Standard Specification for Cold Weather Concreting.
 - e. 350.1, Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures.
 - f. CP-1, Technical Workbook for ACI Certification of Concrete Field Testing Technician – Grade 1.
2. ASTM International (ASTM):
 - a. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - b. C33/C33M, Standard Specification for Concrete Aggregates.
 - c. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - e. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cube Specimens).
 - f. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - g. C150/C150M, Standard Specification for Portland Cement.
 - h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - i. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
 - j. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - k. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
 - l. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.

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- m. C595/C595M, Standard Specification for Blended Hydraulic Cements.
 - n. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - o. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - p. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
 - q. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
 - r. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
 - s. C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method.
 - t. C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
 - u. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
 - v. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
 - w. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
 - x. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
 - y. C1582/C1582M, Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete.
 - z. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
 - aa. D4580, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding.
 - bb. E329, Standard Specification for Agencies Engaged in Construction Inspection, Special Inspection, or Testing Materials Used in Construction.
 - cc. E1155, Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers.
3. National Ready Mixed Concrete Association (NRMCA).

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1.02 DEFINITIONS

- A. Basin Train: Series of interconnected basins that operate as a unit with same water level.
- B. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.
- C. Contractor's Licensed Design Engineer: Individual representing Contractor who is licensed to practice engineering as defined by statutory requirements of professional licensing laws in state or jurisdiction in which Project is to be constructed.
- D. Defective Area: Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4-inch in diameter, cracks in liquid containment structures and below grade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.
- E. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.
- F. Hot Weather: As defined in ACI 305.1.
- G. Hydraulic Structure: Liquid containment structure.
- H. New Concrete: Less than 60 days old.
- I. Slurry Mixture: Mixture of sand, 3/8-inch maximum nominal aggregate size, cement, and water for wall construction joints with waterstop.

1.03 SUBMITTALS

- A. Action Submittals:
 - 1. Mix Designs:
 - a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.

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- b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
 - c. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
 - 1) Portland cement.
 - 2) Fly ash.
 - 3) Slag cement.
 - 4) Aggregates, including specified class designation for coarse aggregate.
 - 5) Admixtures.
 - 6) Concrete producer has verified compatibility of constituent materials in design mix.
 - d. Test Reports:
 - 1) Cement: Chemical analysis report.
 - 2) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
 - 3) Water-Soluble Chloride-Ion Content in Hardened Concrete: Unless otherwise permitted, in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
 - 4) Shrinkage Test Results: In accordance with ASTM C157/C157M as modified herein.
 - e. Aggregates:
 - 1) Coarse Aggregate Gradation: List gradings and percent passing through each sieve.
 - 2) Fine Aggregate Gradation: List gradings and percent passing through each sieve.
 - 3) Percent of fine aggregate weight to total aggregate weight.
 - 4) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 2.
 - 5) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 4.
 - 6) Test Reports:
 - a) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete Mix Design. Include documentation of test results per applicable standards.
 - f. Admixtures: Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.
2. Product Data: Specified ancillary materials.

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3. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details shall include, but not be limited to, the following:
 - a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
 - b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
 - c. Methods for temperature protection during placement.
 - d. Types of covering, insulation, housing, or heating to be provided.
 - e. Curing methods to be used during and following protection period.
 - f. Use of strength accelerating admixtures.
 - g. Methods for verification of in-place strength.
 - h. Procedures for measuring and recording concrete temperatures.
 - i. Procedures for preventing drying during dry, windy conditions.
4. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan shall include, but not be limited to, the following:
 - a. Procedures for measuring, and recording temperatures of reinforcement and other embedded items prior to concrete placement.
 - b. Use of retarding admixture.
 - c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
 - d. Types of shading and wind protection to be provided.
 - e. Curing methods, including use of evaporation retardant.
 - f. Procedures for measuring and recording concrete temperatures.
 - g. Procedures for preventing drying during dry, windy conditions.
5. Thermal Control Plan: For concrete sections with a minimum specified dimension that is greater than 2 feet 6 inches.
6. Concrete repair techniques.

B. Informational Submittals:

1. Preinstallation Conference minutes.
2. Manufacturer's application instructions for bonding agent and bond breaker.
3. Manufacturer's Certificate of Compliance to specified standards:
 - a. Bonding agent.
 - b. Bond breaker.

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4. Statement of Qualification:
 - a. Batch Plant: Certification as specified herein.
 - b. Mix designer.
 - c. Installer.
 - d. Testing agency.
5. Field test reports.
6. Thermal Control Plan: For mass concrete sections in accordance with ACI 301 Section 8, Mass Concrete.
7. Tightness test results.
8. Concrete Delivery Tickets:
 - a. For each batch of concrete before unloading at Site.
 - b. In accordance with ASTM C94/C94M, including requirements 14.2.1. through 14.2.10.
 - c. Indicate amount of mixing water withheld and maximum amount that may be permitted to be added at Site.

1.04 QUALITY ASSURANCE

- A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.
- B. Qualifications:
 1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
 2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of the Work. Requirement may be waived if individual is Contractor's Licensed Design Engineer.
 3. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
 - a. Where field testing is required of Contractor, personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
 - b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

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C. Thermal Control Plan:

1. When required, shall include the following minimum requirements:
 - a. Calculated or measured adiabatic temperature rise of concrete.
 - b. Upper limit for concrete temperature at time of placement.
 - c. Description of specific measures and equipment that will be used to ensure maximum temperature in placement will not exceed specified maximum temperature limit.
 - d. Calculated maximum temperature in placement based on expected conditions at time of placement and use of proposed measures to control temperatures.
 - e. Description of specific measures and equipment that will be used to ensure temperature difference will not exceed specified temperature difference limit.
 - f. Calculated maximum temperature difference in placement based on expected conditions at time of placement and use of proposed measures to control temperature differences.
 - g. Description of equipment and procedures that will be used to monitor and log temperatures and temperature differences.
 - h. Drawing showing locations for temperature sensors in placement.
 - i. Description of format and frequency of providing temperature data to Engineer.
 - j. Description of measures to address and reduce excessive temperatures and temperature differences, if they occur.
 - k. Description of curing procedures, including materials and methods, and curing duration.
 - l. Description of formwork removal procedures to ensure temperature difference at temporarily exposed surface will not exceed temperature difference limit, and how curing will be maintained.
 - m. Alternate temperature limits when permitted by Engineer.
 - 1) Determination of alternate temperature limits shall be based on detailed thermal and crack analyses.
 - 2) Analyses shall be stamped by Contractor's Licensed Design Engineer.
 - n. If concrete design mixture is changed, thermal control plan must be updated.

D. Preinstallation Conference:

1. Required Meeting Attendees:
 - a. Contractor, including pumping, placing and finishing, and curing subcontractors.
 - b. Ready-mix producer.

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- c. Admixture representative.
 - d. Testing and sampling personnel.
 - e. Engineer who authored Statement of Special Inspection Plan or Engineer's designee.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
 - a. Admixture types, dosage, performance, and redosing at Site.
 - b. Mix designs, test of mixes, and Submittals.
 - c. Placement methods, techniques, equipment, consolidation, and form pressures.
 - d. Slump and placement time to maintain slump.
 - e. Finish, curing, and water retention.
 - f. Thermal control plan.
 - g. Protection procedures for weather conditions.
 - h. Other specified requirements requiring coordination.
4. Conference minutes as specified in Section 01 31 19, Project Meetings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cementitious Materials:

1. Cement:
 - a. Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
 - b. Blended Hydraulic Cement:
 - 1) Unless otherwise specified, excluding Type IS (greater than 70), conform to requirements of ASTM C595/C595M.
 - 2) Portland cement used in blended hydraulic cement, conform to requirements of ASTM C150/C150M.
 - c. Furnish from one source.
2. Supplementary Cementitious Materials (SCM):
 - a. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
 - 1) Shall not be produced from process that has utilized hazardous or potentially hazardous materials.
 - 2) ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
 - b. Slag Cement: In accordance with ASTM C989, Grade 100 or Grade 120. Shall not be produced from process that has utilized hazardous or potentially hazardous materials.

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- B. Aggregates: Furnish from one source for each aggregate type used in a mix design.
1. Normal-Weight Aggregates:
 - a. In accordance with ASTM C33/C33M, except as modified herein.
 - 1) Class Designation: 4S unless otherwise specified.
 - b. Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
 - c. Alkali Silica Reactivity: See Article Concrete Mix Design.
 2. Fine Aggregates:
 - a. Clean, sharp, natural sand.
 - b. ASTM C33/C33M.
 - c. Limit deleterious substances in accordance with ASTM C33/C33M, Table 2 and as follows:
 - 1) Limit material finer than 75- μ m (No. 200) sieve to 5 percent mass of total sample.
 - 2) Limit coal and lignite to 1 percent.
 3. Coarse Aggregate:
 - a. Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
 - b. Limit deleterious substances in accordance with ASTM C33/C33M, Table 4 for specified class designation.
- C. Admixtures: Unless otherwise permitted, furnish from one manufacturer.
1. Characteristics:
 - a. Compatible with other constituents in mix.
 - b. Contain at most, only trace amount chlorides in solution.
 - c. Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
 2. Air-Entraining Admixture: ASTM C260/C260M.
 3. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
 - a. Manufacturers and Products:
 - 1) Master Builders Solutions US, Shakopee, MN; MasterPozzoloth Series or MasterPolyheed Series.
 - 2) Euclid Chemical Co., Cleveland, OH; Eucon Series.
 - 3) GCP Applied Technologies., Cambridge, MA; Mira Series.
 4. Retarding Admixture: ASTM C 494/C 494M, Type B.
 5. Accelerating Admixture: ASTM C 494/C 494M, Type C.

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6. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F or Type G.
 - a. Manufacturers and Products:
 - 1) Master Builders Solutions US, Shakopee, MN; MasterGlenium Series or MasterRheobuild 1000.
 - 2) Euclid Chemical Co., Cleveland, OH; Eucon Series or Plastol Series.
 - 3) GCP Applied Technologies, Cambridge, MA; ADVA Series.
 7. Shrinkage Reducing Admixture:
 - a. ASTM C494/C494M, Type S.
 - b. Manufacturers and Products:
 - 1) BASF Admixtures Inc., Shakopee, MN; MasterLife SRA 035 or MasterLife CRA 007.
 - 2) Euclid Chemical Co., Cleveland, OH; Eucon SRA-XT.
 - 3) GCP Applied Technologies Inc., Cambridge, MA; Eclipse 4500.
 8. Do not use calcium chloride as an admixture.
 9. Admixtures with no standard, ASTM or other, designation may be used where permitted.
- D. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water, unless alternative sources of water are permitted.
1. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water shall be less than:
 - a. Chloride Content: 1,000 ppm.
 - b. Sulfate Content as SO₄: 3,000 ppm.
 - c. Alkalis as (Na₂O + 0.658 K₂O): 600 ppm.
 - d. Total Solids by Mass: Less than 50,000 ppm.

2.02 ANCILLARY MATERIALS

A. Bonding Agent:

1. Unless otherwise specified, in accordance with the following:
 - a. ASTM C881/C881M, Type V.
 - b. Two-component, moisture insensitive, 100 percent solids epoxy.
 - c. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.
 - d. Manufacturers and Products:
 - 1) Master Builders Solutions US, Shakopee, MN; MasterInject 1500.

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- 2) Euclid Chemical Co., Cleveland, OH; Euco No. 352 Epoxy System LV.
- 3) Prime Resins, Conyers, GA; Prime Bond 3000 Series to 3900 Series.
- 4) Sika Chemical Corp., Lyndhurst, NJ; Sikadur 32 Hi-Mod.

B. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
 - a. Dayton Superior Corporation, Kansas City, KS; EDOCO Clean Lift Bond Breaker.
 - b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

C. Crack Repair: In accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

2.03 CONCRETE MIX DESIGN

A. General:

1. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
2. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
3. Selection of constituent materials and products in mix design are optional, unless specified otherwise.
4. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range, water-reducing admixture in pumped concrete, in concrete with a water-cementitious materials ratio below 0.50, and in concrete that is part of a liquid-containment structure.
5. Unless otherwise permitted, use water-reducing admixture and high-range, water-reducing admixture in columns, piers, pilasters, and walls.
6. Use water-reducing admixture or high-range, water-reducing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
7. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.

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8. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor, and coordinated with concrete producer. Fresh properties of concrete shall remain stable to satisfaction of Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.
9. Contractor is encouraged to consider using environmentally sustainable concrete mix design technologies such as use of supplementary cementitious materials and aggregate packing.

B. Potential Alkali-aggregate Reactivity of Concrete:

1. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
2. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C1260 or ASTM C1567.
 - a. Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be nondeleteriously reactive in accordance with ASTM C227 or ASTM C1293, with less than 0.04 percent expansion at 1 year for cement-aggregate combinations or less than 0.04 percent expansion at 2 years for combinations with pozzolan or slag.
 - b. Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.
 - c. Use low-alkali cement or incorporate pozzolans into concrete mixture as necessary to satisfy testing for potential alkali reactivity. Alternately, a chemical inhibitor such as a lithium based admixture may be proposed.

C. Proportions:

1. Design mix to meet aesthetic, durability, and strength requirements.
2. Where fly ash is included in mix, minimum fly ash content shall be a minimum of 15 percent of weight of total cementitious materials.

D. Concrete Shrinkage Limits:

1. Where shrinkage limits are specified, design mix for following shrinkage limits and test in accordance with ASTM C157/C157M, with the following modifications:
 - a. Prisms shall be moist cured for 7 days prior to 28-day drying period.

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- b. Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
- c. Reported results shall be average of three prisms.
- d. If shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
- e. Unless otherwise specified, results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used, or exceed 0.038 percent if 4-inch prisms are used. Aggregate will be rejected if test values exceed these limits.

E. Slump Range at Site:

- 1. Prior to submitting mix design, consult with concrete producer and select a target slump value at point of delivery, for each application of each design mix. Unless otherwise permitted, target slump value will then be enforced for duration of Project.
- 2. Design mixes that include a high-range, water-reducing admixture shall have a minimum slump of 2 inches prior to addition of admixture. Unless otherwise permitted, slump shall be 8 inches maximum at point of delivery, for concrete with a high-range, water-reducing admixture.
- 3. Slump tolerance shall meet requirements of ACI 117.

F. Combined Aggregate Gradation:

- 1. Combined Gradation Limits: Fine aggregate shall be in range of 36 percent to 40 percent of total aggregate weight.

2.04 CONCRETE MIXING

A. General: In accordance with ACI 301, except as modified herein.

B. Truck Mixers:

- 1. For every truck, test slump of samples taken per ASTM C94/C94M, Paragraph 12.5.1.
- 2. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

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2.05 TEMPERATURE LIMITS

- A. For concrete sections with a minimum specified dimension that is greater than 2 feet 6 inches, and unless otherwise permitted:
 - 1. Maintain concrete temperature below 95 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
 - 2. Provide documentation that maximum concrete temperature in structure will not exceed 160 degrees F, and maximum temperature differential between center of section and external surfaces of concrete will not exceed 35 degrees F.

2.06 SOURCE QUALITY CONTROL

- A. Source Quality Control Inspection: Engineer shall have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

PART 3 EXECUTION

3.01 PLACING CONCRETE

- A. Preparation: Meet requirements ACI 301, except as modified herein.
- B. Inspection: Notify Engineer and Special Inspector at least 1 full working day in advance before starting to place concrete.
- C. Placement into Formwork:
 - 1. Where vapor retarder or barrier is required, coordinate subgrade preparation with requirements in Division 07, Thermal and Moisture Protection, of these Specifications.
 - 2. Reinforcement: Secure in position before placing concrete.
 - 3. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
 - 4. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.

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5. Use placement devices, for example chutes, pouring spouts, and pumps as required to prevent segregation.
6. Vertical Free Fall Drop to Final Placement:
 - a. Forms 8 Inches or Less Wide: 5 feet.
 - b. Forms Wider than 8 Inches: 8 feet, except as specified.
7. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
8. Do not use aluminum conveying devices.
9. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
10. Joints in Footings and Slabs:
 - a. Ensure space beneath plastic waterstop completely fills with concrete.
 - b. During concrete placement, make visual inspection of entire waterstop area.
 - c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, and place remaining concrete to full height of slab.
 - d. Apply procedure to full length of waterstop.
11. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.
12. Cure concrete as specified in Section 03 39 00, Concrete Curing.

D. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.
4. Conveyor Belts:
 - a. Approved by Engineer.
 - b. Wipe clean with device that does not allow mortar to adhere to belt.
 - c. Cover conveyor belts and chutes.

E. Retempering: Not permitted for concrete where cement has partially hydrated.

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F. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping equipment and hoses (conduits) that are not functioning properly.

G. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Locate expansion, control, and contraction joints where shown on the Drawings.
3. Construction Joints:
 - a. Unless otherwise shown or permitted, locate construction joints as follows:
 - 1) Locate construction joints as shown on the Drawings or where approved in joint location submittal required in Section 03 15 00, Concrete Joints and Accessories.
 - 2) Provide vertical construction joints in walls and slabs at maximum spacing of 40 feet, unless shown or approved otherwise.
 - 3) When vertical expansion, contraction, or control joint spacing does not exceed 60 feet, intermediate construction joints are not required.
 - 4) Uniformly space vertical construction joints within straight sections of walls and slabs, avoiding penetrations.
4. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
5. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

H. Minimum Time between Adjacent Placements:

1. Construction or Control Joints: 7 days unless otherwise specified.
2. Construction Joint Between Top of Footing or Slab, and Column or Wall: As soon as can safely be done without damaging previously cast concrete or interrupting curing thereof, but not less than 24 hours.
3. Expansion or Contraction Joints: 1-day.

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4. For columns and walls with a height in excess of 10 feet, wait at least 2 hours before depositing concrete in beams, girders, or slabs supported thereon.
5. For columns and walls 10 feet in height or less, wait at least 1-hour prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.

I. Consolidation and Visual Observation:

1. Consolidation Equipment and Methods: ACI 301.
2. Provide at least one standby vibrator in operable condition at Site prior to placing concrete.
3. Provide sufficient windows in forms or limit form height to allow for concrete placement through windows and for visual observation of concrete.
4. Vibrate concrete in vicinity of joints to obtain impervious concrete.

J. Hot Weather:

1. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:
 - a. Maintain concrete temperature below 90 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
 - b. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
2. Concrete Curing: As specified in Section 03 39 00, Concrete Curing.

K. Cold Weather Placement:

1. Unless otherwise permitted, shall be in accordance with requirements of ACI 306.1 and as follows:
 - a. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
 - b. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.
 - c. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.

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- d. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
 - e. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.
 - f. Cure concrete as specified in Section 03 39 00, Concrete Curing.
 - g. Protect concrete from freezing until end of curing period and until concrete has attained a compressive strength of 3,500 pounds per square inch or design compressive strength if less than 3,500 pounds per square inch.
2. Provide maximum and minimum temperature sensors placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work. Unless otherwise permitted, record surface temperature of concrete at least once every 12 hours during specified curing period.
 3. External Heating Units: Do not exhaust heater flue gases directly into enclosed area as it causes concrete carbonation as a result of concentrated carbon dioxide.
 4. Maintain curing conditions as specified in Section 03 39 00, Concrete Curing.

3.02 CONCRETE BONDING

- A. Construction Joints in New Concrete Members: Prepare surface of construction joint as specified in Section 03 15 00, Concrete Joints and Accessories.
- B. Construction Joints at Existing Concrete:
 1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 1/4-inch.
 2. Saturate surface with water for 24 hours prior to placing new concrete.

3.03 REPAIRING CONCRETE

- A. General:
 1. Inject cracks that leak with crack repair epoxy as specified in Section 03 64 23, Epoxy Resin Injection Grouting.
 2. Repair defective areas of concrete.
 3. Repair horizontal concrete surfaces in accordance with Section 03 01 33, Repair of Horizontal Concrete Surfaces.
 4. Repair vertical and overhead concrete surfaces in accordance with Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.

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5. Develop repair techniques with material manufacturer on surface that will not be visible in final construction prior to starting actual repair work and show how finish color will blend with adjacent surfaces. Obtain approval from Engineer.
 6. Obtain quantities of repair material and manufacturer's detailed instructions for use to provide repair with finish to match adjacent surface or apply sufficient repair material adjacent to repair to blend finish appearance.
 7. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Engineer.
- B. Tie Holes: Unless otherwise specified, fill with specified repair material. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.
- C. Alternate Form Ties, Through-Bolts:
1. Mechanically roughen entire interior surface of through hole.
 2. Apply bonding agent to roughened surface and drive elastic vinyl plug to half depth.
 3. Dry pack entire hole from both sides of plug with nonshrink grout, as specified in Section 03 62 00, Grouting.
 4. Use only enough water to dry pack grout.
 5. Dry pack while bonding agent is still tacky.
 6. If bonding agent has dried, remove bonding agent by mechanical means and reapply new coat of bonding agent.
 7. Compact grout using steel hammer and steel tool to drive grout to high density.
 8. Cure grout with water.
- D. Exposed Metal Objects:
1. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1 inch and then cutting or removing metal object.
 2. Repair area of chipped-out concrete as specified for defective areas.
- E. Blockouts at Pipes or Other Penetrations: Where shown install in accordance with requirements of the Drawings.

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3.04 CONCRETE WALL FINISHES

A. Type W-1 (Ordinary Wall Finish):

1. Patch tie holes.
2. Knock off projections.
3. Repair defective areas.
4. Inject cracks in accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

B. Type W-2 (Smooth Wall Finish):

1. Patch tie holes.
2. Grind off fins and other projections.
3. Repair defective areas to provide smooth uniform appearance.
4. Inject cracks in accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

3.05 CONCRETE SLAB FINISHES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
2. Do not use "jitterbugs" or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
3. Finish slab in accordance with specified slab finish.
4. Do not dust surfaces with dry materials nor add water to surfaces.
5. Cure concrete as specified in Section 03 39 00, Concrete Curing.

B. Type S-1 (Steel Troweled Finish):

1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation.
2. Wood float to true, even plane with no coarse aggregate visible.
3. Use sufficient pressure on wood floats to bring moisture to surface.
4. After surface moisture has disappeared, hand steel trowel concrete to produce smooth, smooth dense surface, free from trowel marks.
5. Provide light steel-troweled finish (two trowelings) at air-entrained slabs. Provide hard steel-troweled finish (ringing sound from the trowel) for nonair-entrained slabs.
6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.

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7. Power Finishing:
 - a. Approved power machine may be used in lieu of or in addition to hand finishing in accordance with directions of machine manufacturer.
 - b. Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high and low spots in slab.
 - c. Do first steel troweling for slab S-1 finish by hand.
- C. Type S-2 (Wood Float Finish):
 1. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.
 2. Wood float finish to compact and seal surface.
 3. Remove laitance and leave surface clean.
 4. Coordinate with other finish procedures.
- D. Type S-5 (Broomed Finish):
 1. Finish as specified for Type S-1 floor finish, except use only a light-steel troweled finish, and then finish surface by drawing fine-hair broom lightly across surface.
 2. Broom in same direction and parallel to expansion joints, or, in case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.
- E. Type S-6 (Sidewalk Finish):
 1. Slope walks down 1/4-inch per foot away from structures, unless otherwise shown.
 2. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
 3. Broom surface at right angles to direction of traffic or as shown.
 4. Lay out sidewalk surfaces in blocks, as shown or as directed by Engineer, with grooving tool.
- F. Concrete Curbs:
 1. Float top surface of curb smooth, and finish all discontinuous edges with steel edger.
 2. After concrete has taken its initial set, remove front form and give exposed vertical surface an ordinary wall finish, Type W-1.

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3.06 CONCRETE SLAB TOLERANCES

A. Slab Tolerances:

1. Exposed Slab Surfaces: Comprise of flat planes as required within tolerances specified.
2. Slab Finish Tolerances and Slope Tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end blocks, nor low spots that allow block of twice the tolerance in thickness to pass under supported 10-foot straightedge.
3. Slab Type S-A: Steel gauge block 5/16-inch thick.
4. Slab Type S-B: Steel gauge block 1/8-inch thick.
5. Slab Type S-A and S-B: Finish Slab Elevation. Slope slabs to floor drain and gutter, and shall adequately drain regardless of tolerances.
6. Thickness: Maximum 1/4-inch minus or 1/2-inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2-inch plus.

B. Slab Elevation and Thickness:

1. Finish Slab Elevation: Slope slabs to floor drains and gutter. Slabs shall adequately drain regardless of tolerances.
2. Thickness: Maximum 1/4-inch minus or 1/2-inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2-inch plus.

3.07 BACKFILL AGAINST STRUCTURES

- A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.
- B. Refer to General Structural Notes on the Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.
- C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.08 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test specimens onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Unless otherwise specified, sample concrete for testing for making test specimens, from point of delivery.
3. When concrete is pumped, sample and test air content at point of delivery and at point of placement.
 - a. For Each Concrete Mixture: Provided results of air content tests for first load of the day are within specified limits, testing need only be performed at point of delivery for subsequent loads of that concrete mixture except that testing should be performed at point of placement every 4 hours.
4. Evaluation will be in accordance with ACI 301 and Specifications.
5. Test specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
6. Frequency of testing may be changed at discretion of Engineer.
7. Pumped Concrete: Take concrete samples for slump, ASTM C143/C143M, and test specimens, ASTM C31/C31M and ASTM C39/C39M.
8. If measured air content at delivery is greater than specified limit, check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents. Concrete that has failed to meet requirements of Contract Documents shall be rejected.

B. Concrete Strength Test:

1. Unless otherwise specified, one specimen at age of 7 days for information, and two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 28 days for acceptance.

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2. Concrete with specified 56-day strength, test one specimen at age of 7 days for information, two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 28 days for acceptance, and two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 56 days for acceptance. Should results of 28-day tests meet specified requirement for 56-day strength, 56-day tests will not be required.
3. If result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified in Section 03 39 00, Concrete Curing, by 7 additional days.
4. Provide a minimum of one spare test specimen per sample. Test spare cylinder as directed by Engineer.

C. Shrinkage Tests:

1. When required to conform to shrinkage limits, collect actual concrete materials being batched and before liquids have been added to mix.
2. Mix sampled material in a laboratory at proportions matching batched concrete.
3. Test shrinkage characteristics every 5,000 cubic yards of concrete used on job and every 3 months during construction when compression test cylinders are made.
4. Concrete Shrinkage Limits:
 - a. Test in accordance with ASTM C157/C157M, with the following modifications:
 - 1) Prisms shall be moist cured for 7 days prior to 28-day drying period.
 - 2) Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
 - 3) Reported results shall be average of three prisms.
 - 4) If drying shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
 - 5) Results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used, or exceed 0.038 percent if 4-inch prisms are used.
 - 6) If 7-day or 14-day shrinkage tests results exceed shrinkage limits established by design mix testing, furnish additional 14 days of water curing beyond original curing period, for concrete surfaces of hydraulic structures represented by prisms. Modify concrete mix design to reduce shrinkage prior to casting additional concrete on Project.

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- D. High-Range, Water-Reducer (Superplasticizer) Admixture Segregation Test:
Test each truck prior to use on Project.
1. Segregation Test Objective: Concrete with 4-inch to 8-inch slump shall stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump test.
 2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
 3. Reject concrete if mortar or moisture separates and flows out of mix.
- E. Cold Weather Placement Tests:
1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
 - a. Six extra test cylinders from last 100 cubic yards of concrete.
 - b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
 2. These specimens shall be in addition to those cast for lab testing.
 3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
 4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
 5. Test cylinders in accordance with applicable sections of ASTM C31/C31M and ASTM C39/C39M.
 6. Use test results to determine specified strength gain prior to falsework removal or for prestressing.
- F. Tolerances:
1. Walls: Measure and inspect walls for compliance with tolerances specified in Section 03 10 00, Concrete Forming and Accessories.
 2. Slab Finish Tolerances and Slope Tolerances:
 - a. Make floor flatness measurements day after floor is finished and before shoring is removed to eliminate effects of shrinkage, curing, and deflection.
 - b. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
 - c. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

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G. Liquid Tightness Tests:

1. Purpose: To determine integrity and liquid-tightness of finished exterior and interior concrete surfaces of liquid containment structures.
2. Test the following structures for liquid-tightness:
 - a. New UV Channel
3. Water source will be Owner.
 - a. Provide means to transport water to structure to be tested.
 - b. If additional tightness tests are required because of failure to meet criteria, provide water for subsequent tests.
4. After testing has been completed, dispose of test water in a manner approved by Owner.
5. Liquid-Tightness Test Requirement:
 - a. Perform tightness tests in accordance with ACI 350.1 and as specified herein.
 - b. Do not place backfill or install brick facing, grout topping slab, coatings, or other work that will cover concrete surfaces until tightness testing has been completed and approved.
 - c. Measure evaporation, precipitation, and temperature as specified.
6. Measure water surface at two points 180 degrees apart when possible where attachments, such as ladders exist, at 24-hour intervals.
7. Acceptance Criteria:
 - a. Acceptance of containment structure must be based on criteria for both Part 1 and Part 2. Containment structures must be retested until compliance is achieved.
 - b. Part 1, Qualitative: If moisture is observed on containment structure surfaces, exterior to contained liquid, where moisture can be picked up on a dry hand, containment structure is noncompliant.
 - c. Part 2, Quantitative:
 - 1) Volume loss must not exceed 0.050 percent of contained liquid volume per 24-hour period, adjusted for evaporation, precipitation, and temperature.
 - 2) Acceptance that structure has passed Part 2 of tightness test must be based on total volume loss at end of specified test period.
8. Repairs When Test Fails:
 - a. Dewater structure; fill leaking cracks with crack repair epoxy as specified in Section 03 64 23, Epoxy Resin Injection Grouting.
 - b. Patch areas of damp spots previously recorded, and repeat water leakage test in its entirety until structure successfully passes test.

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3.09 MANUFACTURER'S SERVICES

- A. Provide representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.
 - 1. Concrete Producer Representative:
 - a. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
 - b. Establish control limits on concrete mix designs.
 - c. Provide equipment for control of concrete redosing for air entrainment or high-range, water-reducing admixture, superplasticizers, at Site to maintain proper slump and air content if needed.
 - 2. Admixture Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.
 - 3. Bonding Agent Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.

3.10 PROTECTION OF INSTALLED WORK

- A. After curing as specified in Section 03 39 00, Concrete Curing, and after applying final floor finish, cover slabs with plywood or particle board or plastic sheeting or other material to keep floor clean and protect it from material and damage as a result of other construction work.
- B. Repair areas damaged by construction, using specified repair materials and approved repair methods.

3.11 SCHEDULE OF CONCRETE FINISHES

- A. Form Tolerances: As specified in Section 03 10 00, Concrete Forming and Accessories.
- B. Special Floor Finishes: As specified in Section 03 35 00, Concrete Finishing.

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C. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form Tolerances
Exterior Wall Surfaces		
Backfilled/waterproofed (below point 6" below finish grade)	W-1	W-A
Backfilled/not waterproofed (below point 6" below final grade)	W-1	W-A
Interior Wall Surfaces		
Open top water-holding tanks and basins/not painted or coated	W-2	W-A
Exterior Slabs		
Water-holding tanks and basins/top of wall	S-5	S-B
Top of footing	S-2	S-A
Sidewalks	S-6	S-B
Other exterior slabs	S-5	S-A
Interior Slabs		
Hydraulic channels	S-1	S-A

3.12 SUPPLEMENTS

A. Requirements of concrete mix designs following "End of Section," are a part of this specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, Class 5000F3S1W2C2.
2. Concrete Mix Design, Class 3500F1S1W0C1.

END OF SECTION

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CONCRETE MIX DESIGN, CLASS 5000F3S1W2C2

- A. Mix Locations: Typical, unless otherwise specified.
- B. Exposure Categories and Classifications: F3S1W2C2 as defined in ACI 318-19.
- C. Mix Properties:
1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
 2. Minimum concrete compressive strength (f'c) must be 5,000 pounds per square inch at 28 days.
 3. Designed to conform to shrinkage limits.
 4. Air-entraining admixtures are prohibited in concrete mixtures and total air content must not be greater than 3 percent, for the following:
 - a. Slabs to receive hard-troweled finish.
 5. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in.‡	Air Content (%)*
3/4	6.0
1	6.0
1-1/2	5.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is +1-1/2 percent.

§Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.

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6. Limit supplementary cementitious materials as follows:

Limits on Cementitious Materials for Concrete Assigned to Exposure Class F3 ‡*	
Supplementary Cementitious Materials	Maximum Percent of Total Cementitious Materials by Mass
Fly as or natural pozzolans conforming to ASTM C618	25
Slag cement conforming to ASTM C989	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or natural pozzolans and silica fume	35
Total of fly ash or natural pozzolans, slag cement, and silica fume	50
‡Supplementary cementitious materials, including fly ash and natural pozzolans, slag cement, and silica fume, used in the manufacture of ASTM C595/C595M blended cements shall be included in assessing compliance with these limits. *The individual limits shall apply regardless of the number of cementitious materials in a concrete mixture.	

7. Provide cementitious materials in accordance with one of the following:
- ASTM C595 Type IL, MS, moderate sulfate resistance. Mixes containing ASTM C595 IL cementitious materials shall include a corrosion inhibiting admixture.
 - ASTM C150/C150M Type II or Type V; inclusion of supplementary cementitious materials in design mix is optional.
 - ASTM C150/C150M types other than Type II or Type V, plus supplementary cementitious materials in accordance with one of the following:
 - Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
 - Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.

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- d. ASTM C595/C595M Types excluding Type IS (greater than 70), conforming to ASTM C595/C595M and having (MS) designation.
 - 1) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
- e. ASTM C1157/C1157M having (MS) designation.
- 8. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
 - a. Limits are stated in terms of water-soluble chloride ions (Cl^-) in percent by mass of cementitious materials.
 - b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
- D. Refer to Part 1 through Part 3 of this section for additional requirements.

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CONCRETE MIX DESIGN, CLASS 3500F1S1W0C1

A. Mix Locations:

1. Electrical duct banks.
2. Pipe encasements that are not cast monolithically with concrete base mats or slabs.
3. Concrete curbs and sidewalks.
4. Where specified in Contract Documents.

B. Exposure Categories and Classifications: F1S1W0C1 as defined in ACI 318-19.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 3,500 pounds per square inch at 28 days.
3. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
3/4	5.0
1	4.5
1-1/2	4.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is +1-1/2 percent.

§Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.

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4. Provide cementitious materials in accordance with one of the following:
 - a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
 - b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
 - 1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
 - 2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
 - 3) ASTM C595/C595M Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
 - a) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
 5. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified.
 - a. Limits are stated in terms of water-soluble chloride ions (Cl^-) in percent by mass of cementitious materials.
 - b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
- D. Refer to Part 1 through Part 3 of this section for additional requirements.

**SECTION 03 39 00
CONCRETE CURING**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI): 308.1, Specification for Curing Concrete.
 2. ASTM International (ASTM):
 - a. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - b. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
 3. NSF International: 61, Drinking Water System Components – Health Effects.

1.02 SUBMITTALS

- A. Action Submittals:
1. Manufacturers' data indicating compliance with the requirements specified herein for the following products:
 - a. Exposed aggregate finish retardant on formed surface.
 - b. Evaporation retardant.
 - c. Curing compound.
 - d. Penetrating water repellent sealer.
 - e. Clear liquid densifier.
 2. Curing methods proposed for each type of element such as slab, walls, beams, and columns in each facility.
- B. Informational Submittals:
1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
 - a. Curing compound showing moisture retention requirements.
 - b. Retardants for exposed aggregate finish.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315 Type I, Class A.
2. Manufacturers and Products:
 - a. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
 - b. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
 - c. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
 - d. Dayton Superior; Safe Cure and Seal 1315 EF.
 - e. BASF Construction Chemicals., Shakopee, MN; MasterKure CC 200WB.
 - f. Euclid Chemical Co., Cleveland, OH; EucoCure VOX.
 - g. Euclid Chemical Co., Cleveland, OH; Kurez VOX White Pigmented.

B. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
 - a. BASF Construction Chemicals, Shakopee, MN; MasterKure ER 50.
 - b. Euclid Chemical Co., Cleveland, OH; Eucobar.

C. Penetrating Water Repellent Sealer: Water based, ready to use, single component, silane/siloxane, penetrating, clear water repellent sealer.

1. Viscosity: 50 cps.
2. Flash Point: 200 degrees F.
3. NCHRP No. 244 Reduction in Chloride Content:
 - a. Average: 82 percent.
 - b. Minimum Required: 75 percent.
4. NCHRP No. 244 Reduction in Weight Gain:
 - a. 21 Days: 85 percent.
 - b. VOCs: 50 g/l.
 - c. Depth of Penetration: 1/4-inch.
5. Manufacturers and Products:
 - a. BASF Construction Chemicals, Shakopee MN; MasterProtect H 400.
 - b. Euclid Chemical Co.; Baracade WB 244.

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D. Clear Liquid Densifier:

1. Colorless, aqueous solution of magnesium fluorosilicate.
2. Each gallon of solution shall contain a minimum of 2 pounds of fluorosilicate compound.
3. Manufacturers and Products:
 - a. BASF Construction Chemicals, Shakopee, MN; MasterKure HD 300WB.
 - b. Euclid Chemical Co., Cleveland, OH; Surfhard.

E. Retardant for Exposed Aggregate Finish on Slabs:

1. Manufacturers and Products:
 - a. Sika Chemical Corp., Lyndhurst, NJ; Rugasol.
 - b. Conrad Sovig Co., San Francisco, CA; Conreveal Top Surface.
 - c. Burke Co., San Mateo, CA; Burke True Etch Surface Retarder.
 - d. Euclid Chemical Co., Cleveland, OH; Surface Retarder S.

F. Retardant for Exposed Aggregate Finish on Formed Surface:

1. Manufacturers and Products:
 - a. L. M. Scofield Co., Los Angeles, CA; Lithotex Top Surface Retarder.
 - b. Conrad Sovig Co., San Francisco, CA; Control Set.
 - c. Burke Co., San Mateo, CA; Burke True Etch Surface Retarder.
 - d. Euclid Chemical Co., Cleveland, OH; Surface Retarder F.

G. Water: Clean and potable, containing less than 500 ppm of chlorides.

PART 3 EXECUTION

3.01 CONCRETE CURING

A. General:

1. Cure all concrete in accordance with project specifications and ACI308.1.
2. Where surfaces are to receive coatings, painting, cementitious material, or other similar finishes, use only water curing procedures. Refer to Interior Finish Schedule for surfaces to receive coatings.
3. Use only water curing on potable water structures.
4. Where curing compound cannot be used, water curing as described below or special methods using moisture shall be agreed upon by Engineer prior to placing concrete.

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5. As required in Section 03 30 00, Cast-in-Place Concrete, if result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified below, by 7 additional days.
- B. Use one of the following methods as approved by Engineer:
1. Vertical Surfaces:
 - a. Method 1: Leave concrete forms in place and keep surfaces of forms and concrete wet for 7 days.
 - b. Method 2: Continuously sprinkle with water 100 percent of exposed surfaces for 7 days starting immediately after removal of forms.
 - c. Method 3: Apply curing compound, where allowed, immediately after removal of forms.
 2. Horizontal Surfaces:
 - a. Method 1: Protect surface by water ponding for 7 days.
 - b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.
 - c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet for 7 days.
 - d. Method 4: Continuously sprinkle exposed surface for 7 days.
 - e. Method 5: Apply curing compound, where allowed, immediately after final finishing when surface will no longer be damaged by traffic.

3.02 EVAPORATION RETARDANT APPLICATION

- A. Use on flatwork when environmental conditions are anticipated to cause rapid drying of the concrete surface. Do not use evaporation retardant on potable water structures, unless product is NSF 61 approved.
- B. Spray onto surface of fresh flatwork concrete immediately after screeding to react with surface moisture.
- C. Reapply as needed to ensure a continuous moist surface until final finishing is completed.

3.03 PENETRATING WATER REPELLENT SEALER APPLICATION

- A. Before application and with Work above completed, water cure concrete walls and floors for a minimum of 28 days to receive sealer, keep clean, unpainted, and free from membrane curing compounds.

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- B. Concrete to receive penetrating sealer shall be dry for a minimum 24 hours immediately prior to application.
- C. Apply per manufacturer's recommendations utilizing low pressure airless spray equipment. Actual coverage and number of coats to be determined by field test sample application and water absorption testing. Final approval by Owner is required.
- D. Apply at a coverage rate of 125 square feet per gallon to 200 square feet per gallon. Cure penetrating sealer on slabs for the minimum time recommended by manufacturer prior to allowing foot or vehicular traffic.

3.04 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.
- B. Provide penetrating water repellent sealer manufacturer's representative to demonstrate proper application of product.
- C. Provide clear liquid densifier manufacturer's representative to demonstrate proper mixing and application of product.
- D. Provide curing compound manufacturer's representative to demonstrate proper application of curing compound to show coverage in one coat.
- E. Provide retardant for exposed aggregate surfaces manufacturer's representative to demonstrate proper application and surface mortar removal procedures.

END OF SECTION

SECTION 03 62 00
GROUTING

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 SUBMITTALS

A. Action Submittals:

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

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B. Informational Submittals:

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

1.03 QUALIFICATIONS

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

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PART 2 PRODUCTS

2.01 NONSHRINK GROUT AND EPOXY GROUT SCHEDULE

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

Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Blockouts for gate guides	I or II		II
Baseplates for pipe supports, nonvibratory equipment	II	II	II
Form Tie-Through bolt openings	II	II	II

2.02 NONSHRINK GROUT

- A. Category I:
1. Nonmetallic and nongas-liberating.
 2. Prepackaged natural aggregate grout requiring only the addition of water.
 3. Test in accordance with ASTM C1107/C1107M:
 - a. Grout shall have flowable consistency.
 - b. Flowable for 15 minutes.
 4. Grout shall not bleed at maximum allowed water.
 5. Minimum strength of flowable grout, 3,000 pounds per square inch at 3 days, 5,000 pounds per square inch at 7 days, and 7,000 pounds per square inch at 28 days.
 6. Manufacturers and Products:
 - a. Master Builders Solutions, Shakopee, MN; MasterFlow 100.
 - b. Euclid Chemical Co., Cleveland, OH; NS Grout.
 - c. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.
 - d. US MIX Co., Denver, CO; US SPEC GP Grout.
 - e. Five Star Products Inc., Fairfield, CT; Five Star Grout.

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B. Category II:

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

C. Category III:

1. Metallic and nongas-liberating.
2. Prepackaged aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
 - a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
 - b. Temperatures of 40 degrees F and 100 degrees F.
5. One hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 4,000 pounds per square inch at 1 day, 5,000 pounds per square inch at 3 days, and 9,000 pounds per square inch at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.

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8. Manufacturer and Product:
 - a. Master Builders Solutions, Shakopee, MN; MasterFlow 885.
 - b. Euclid Chemical Co, Cleveland, OH; Hi-Flow Metallic Grout.

2.03 EPOXY GROUT

- A. High-strength, nonshrink, high-temperature epoxy grouting material developed for the support of heavy equipment with vibratory loads.
- B. Three-component mixture of a two-component epoxy resin system (100 percent solids) with a graded, precision aggregate blend.
- C. Premeasured, prepackaged system.
- D. Flowable.
- E. Minimum compressive strength in accordance with ASTM C579 Method B, 9,500 pounds per square inch at 75 degrees F at 7 days, 11,000 pounds per square inch at post cure.
- F. Maximum creep resistance in accordance with ASTM C1181 at 600 pounds per square inch, 140 degrees F; $6.0 \text{ by } 10^{-3} \text{ in/in}$.
- G. Minimum bond strength in accordance with ASTM C882, 2,000 pounds per square inch.
- H. Minimum tensile strength in accordance with ASTM C307, 2,000 pounds per square inch.
- I. Maximum coefficient of thermal expansion in accordance with ASTM C531 at 73 degrees F to 210 degrees F, $23.0 \text{ by } 10^{-6} \text{ in/in/degrees F}$.
- J. Working Time: Minimum 2 hours at 50 degrees F; 1.5 hours at 70 degrees F; 50 minutes at 90 degrees F.
- K. Good chemical resistance.
- L. Good effective bearing area.
- M. Noncorrosive.
- N. Moisture insensitive.
- O. Modify resin and aggregate content where recommended by epoxy grout manufacturer to provide desired epoxy grout flow properties.

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P. Manufacturer and Product:

1. Master Builders Solutions, Shakopee MN; MasterFlow 648.
2. Euclid Chemical Co., Cleveland, OH; E³-Series.
3. Dayton Superior Corp., Miamisburg, OH; Pro-Poxy 2000 Normal Set.
4. Five Star Products Inc., Fairfield, CT; DP Epoxy Grout.

PART 3 EXECUTION

3.01 GENERAL

- A. Unless otherwise specified, prepare and condition concrete substrate in accordance with grout manufacturer's training instructions.
- B. Mix, place, and cure grout in accordance with grout manufacturer's representative's training instructions.
- C. Epoxy Grout: Concrete slab shall be fully cured for 28 days to ensure excess water has evaporated. Test concrete surface for moisture in accordance with ASTM D4263 before epoxy grout is placed.
- D. Form Tie-Through Bolt Holes: Provide nonshrink grout, Category II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes; coordinate dry pack dense grout application with vinyl plug in Section 03 10 00, Concrete Forming and Accessories, and bonding agent in Section 03 30 00, Cast-in-Place Concrete.
- E. Form Snap-Tie Hole: Fill tie hole in accordance with requirements of Section 03 30 00, Cast-in-Place Concrete.

3.02 FIELD QUALITY CONTROL

- A. General:
 1. Performed by Project representative's inspection staff.
 2. Perform the following quality control inspections. Grout manufacturer's representative shall accompany the Project representative's inspection staff on the first installation of each size and type of equipment.
- B. Evaluation and Acceptance of Nonshrink Grout:
 1. Inspect surface preparation of concrete substrates onto which nonshrink grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.

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2. Inspect preparation and application of nonshrink grout form work for conformance to the manufacturer's recommendations.
3. Conduct a final review of completed nonshrink grout installation for conformance to these Specifications.
4. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
5. Perform flow cone and bleed tests and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/C1107M.
6. For large grout applications, make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
7. Consistency: As specified in Article Nonshrink Grout. Flow cone test in accordance with ASTM C939. Grout with consistencies outside range requirements shall be rejected.
8. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
9. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.
10. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
11. Perform bleeding test in accordance with ASTM C940 to demonstrate grout will not bleed.
12. Store cubes at 70 degrees F.
13. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.
14. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

C. Evaluation and Acceptance of Epoxy Grout:

1. Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer's requirements.
2. Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
3. Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.
4. Inspect the epoxy-primed metallic substrate for coverage and adhesion.

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5. Inspect preparation and application of epoxy grout form work for conformance to the manufacturer's recommendation.
6. Verify consistency obtained is sufficient for the proper field placement at the installed temperatures.
7. Inspect and record that the "pot life" of epoxy grout materials is not exceeded during the installation.
8. Inspect epoxy grout for cure.
9. Inspect and record that localized repairs made to grout voids are in conformance with the specification requirements.
10. Conduct a final review of completed epoxy grout installation for conformance to these Specifications.
11. Compression tests and fabrication of specimens for epoxy grout shall be made in accordance to ASTM C579, Method B, at intervals during construction as selected by the Project representative. Set of three specimens shall be made for testing at 7 days, and each earlier time period as appropriate.
12. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C579.
13. Grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

3.03 MANUFACTURER'S SERVICES

A. General:

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

B. Nonshrink Grout Training:

1. Training is required for all Type II grout installations.
2. Provide nonshrink grout installation training by the qualified grout manufacturer's representative for Contractor's workers that will be installing nonshrink grout for baseplates and equipment mounts. Schedule training to allow Engineer's attendance.

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3. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and form tie-through bolt holes to provide actual on-the-job training.
4. Use minimum of two bags for each grout Category II and Category III. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Include recommended grout curing methods in the training.
6. Mix and demonstrate patching through-bolt holes and blockouts for gate guides, and similar items.
7. Transport test cubes to independent test laboratory and obtain test reports.
8. Training by manufacturer's representative does not relieve Contractor of overall responsibility for this portion of the work.
9. Submit a list of attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

C. Epoxy Grout Training:

1. Provide epoxy grout installation training by the qualified epoxy grout manufacturer's representative for Contractor's workers that will be installing epoxy grout for equipment mounts. Schedule training to allow Engineer's attendance.
2. Include training in:
 - a. Performance testing such as compressive strength testing of epoxy grout.
 - b. All aspects of using the products, from mixing to application.
3. Transport test cubes to independent test laboratory and obtain test reports.
4. Training by manufacturer's representative does not relieve Contractor of overall responsibility for this portion of the work.
5. Submit a list of attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

3.04 SUPPLEMENT

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

END OF SECTION

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SUPPLEMENT 1

(Test Lab Name)

(Address)

(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

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

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

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

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

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

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

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

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GROUT TESTING PROCEDURES

A. Bagged Material:

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

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

B. Mixing and Consistency Determination:

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

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

D. Bleed Test:

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

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5. Visually check for bleeding of water at 15-minute intervals for 2 hours.
6. Perform final observation at 24 hours.

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

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

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

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

Qualified

Disqualified

F. 24-hour Strength Test:

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

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

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

Signature of Independent Testing Laboratory

Date Test Conducted

SECTION 03 63 00
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM):
 - a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
 - 3. International Code Council (ICC):
 - a. 2021 International Building Code (IBC).
 - b. Evaluation Services Reports.

1.02 DEFINITIONS

- A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.
- B. Special Inspection: As defined in the ICC IBC and indicated on the Statement of Special Inspection (Plan) on the Drawings.

1.03 SUBMITTALS

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

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: At least three similar projects with same products within last 3 years.
2. Installer: Trained and certified by manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2021 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
5. Disposable, Self-Contained Cartridge System:
 - a. Capable of dispensing both components in proper mixing ratio.
 - b. Fit into manually or pneumatically operated caulking gun.
6. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.

SALMON CREEK TREATMENT PLANT
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7. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; HIT-RE 500 V3 (ESR-3814) or HIT HY 200 (ESR 3187) Adhesive Anchors.
 - b. Powers Fasteners, Brewster, NY; Power PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508).
- B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.
- C. Reinforcing Dowels: As specified in Section 03 21 00, Steel Reinforcement.

PART 3 EXECUTION

3.01 INSTALLATION

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

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UV SYSTEM REPLACEMENT

E. Adhesive:

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

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

- A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspection (Plan) on the Drawings. Contractor responsibilities and related information on special inspection and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.
1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01 45 33, Special Inspection, Observation, and Testing.
 2. Continuous inspection required where noted on the Drawings and where concrete dowels are installed in overhead applications.
 3. Periodic inspection required where continuous inspection is not specified.
 4. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report including the following:
 - a. Product Description: Product name, rod diameter, and length.
 - b. Drill bit compliance.
 - c. Hole diameter, diameter, and depth and cleanliness.
 - d. Adhesive expiration date.
 5. Verification of dowel installation in accordance with manufacturer's published instructions
- B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 03 64 23
EPOXY RESIN INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C882, Standard Specification for Test Method for Bond Strength of Epoxy Resin System Used with Concrete by Slant Shear.
 - b. D570, Standard Test Method for Water Absorption of Plastics.
 - c. D638, Standard Test Method for Tensile Properties of Plastics.
 - d. D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
 - e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
 - f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 2. National Sanitation Foundation (NSF):
 - a. Standard 60, Standard for Drinking Water Treatment and Chemicals-Health Effects.
 - b. Standard 61, Standard for Drinking Water System Components-Health Effects.

1.02 DEFINITIONS

- A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.
- B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.
- C. Hydraulic Structure: Liquid containment structure and/or structure designed to mitigate liquid infiltration.
- D. Injection: Method of bonding together, addressing or eliminating leakage through cracks or joints by installing resin under pressure to fill the void in crack or joint.
- E. Joint: A planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements and may contain embedded waterstops.

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- F. Leak or Leakage: Crack or joint exhibiting presence of moisture, sign of efflorescence, intermittently wet to touch, or continuous flow of liquid.
- G. Narrow Cracks: Width equal to or less than 0.015 inch.
- H. Wide Cracks: Wider than 0.015 inch.

1.03 SUBMITTALS

A. Action Submittals:

- 1. Physical and chemical properties for epoxy resin.
- 2. Technical data for metering, mixing, and injection equipment.
- 3. Depth of penetration, length, material used, and procedures where epoxy is approved for use.
- 4. Marked up drawings of proposed epoxy injection repair crack locations, widths, and lengths and direction on structure.
- 5. Sample bottle.
- 6. Pot Life Test.
- 7. Slant Shear Test (Bond Strength).

B. Informational Submittals:

- 1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy resins.
- 2. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements. Certified test results for each batch of epoxy resin.
- 3. Statements of Qualification for Epoxy Resin:
 - a. Manufacturer's Site representative.
 - b. Injection applicator.
 - c. Injection pump operating technician.
- 4. Sample of epoxy resin two component ratio and injection pressure test records for concrete crack repair work.
- 5. Installation instructions for repairing core holes with repair mortar.
- 6. Test results of epoxy resin bond tests.
- 7. Epoxy resin two component ratio and injection pressure test records for concrete crack repair work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staffs:

1. Manufacturer's Site Representative:
 - a. Capable of instructing successful methods of epoxy injection process for concrete structure.
 - b. Understands and is capable of explaining technical aspects of correct material selection and use.
 - c. Experienced in operation, maintenance, and troubleshooting of application equipment.
2. Injection Crew and Job Foreman:
 - a. Provide written and verifiable evidence showing compliance with the following requirements:
 - 1) Licensed or certified by epoxy resin material manufacturer.
 - 2) Minimum 3 years' experience in successful epoxy 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.

B. Injected Epoxy Resin:

1. Fill cracks and joints with minimum resin depth penetration no less than 90 percent of:
 - a. Full thickness of concrete section for cracks or joints.
 - b. Depth between waterstop and inside or outside face of structure for joints with an embedded waterstop.

C. Injected cracks and joints which leak shall be considered deficient work irrespective of depth of penetration. Reinjection of deficient work or, with approval of Engineer, provide other repairs to eliminate leakage.

D. Bond Strength Test for Epoxy Resin:

1. Concrete failure before resin failure.
2. 1,500 pounds per square inch minimum bond strength per ASTM C882 test requirements with no failure of either concrete or epoxy resin.

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1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package resin material in new sealed containers and label with following information:
 - a. Manufacturer's name.
 - b. Product name and lot number.
 - c. ANSI Hazard Classification.
 - d. ANSI recommended precautions for handling.
 - e. Mix ratio by volume for components.

- B. Storage and Protection: Store epoxy resin material containers in accordance with manufacturer's printed instructions and at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and accessories specified in this section shall be products of:

1. BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; SCB Concrese Series products that meet properties indicated in Paragraph Uncured Resin Properties.
2. Sika Corp., Lyndhurst, NJ; Sikadur Series products that meet properties below.
3. Euclid Chemical Co., Cleveland, OH; Euco Series (#452) products that meet properties below.

2.02 EPOXY INJECTION RESIN

- A. Two-component A and B structural epoxy resin for injection into cracks or joints or other voids in concrete structures for bonding or grouting.

B. Uncured Resin Properties:

1. When mixed in ratio specified on resin container label:

	Test Method	Wide Cracks	Narrow Cracks
Pot Life (60-gram mass) @ 77, plus or minus 4 deg F	As specified in Article Source Quality Control	13 to 25 minutes	15 to 30 minutes
Pot Life (60-gram mass) @ 100, plus or minus 4 deg F	As specified in Article Source Quality Control	3 to 10 minutes	10 to 20 minutes

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	Test Method	Wide Cracks	Narrow Cracks
Viscosity @ 40, plus or minus 3 deg F	Brookfield RVT Spindle No. 4 @ 20 rpm	4,400 cps	600 cps
Viscosity @ 75 to 77 deg F	Brookfield RVT Spindle No. 2 @ 20 rpm	375 to 350 cps	175 to 140 cps

- C. Epoxy Resin Properties: When cured for 7 days at 77 degree F, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Ultimate Tensile Strength, psi	ASTM D368	8,000 min.	5,000 min.
Tensile Elongation @ Break, percent	ASTM D638	4.2 max.	3.0 max.
Flexural Strength, psi	ASTM D790	10,000 min.	10,000 min.
Flexural Modulus, psi	ASTM D790	5.5 x 10 ⁵ min.	4.5x10 ⁵ min.
Compressive Yield Strength, psi	ASTM D695*	15,000 min.	12,000 min.
Compressive Modulus, psi	ASTM D695*	4.0x10 ⁵ min.	4.0x10 ⁵ min.
Heat Deflection Temperature	ASTM D648*	130 deg F min.	140 deg F min.
Cured 3 days @ 40 deg F – Wet Concrete		3,500 psi min.	3,500 psi min.
Cured 1 day @ 77 deg F – Dry Concrete		5,000 psi min.	5,000 psi min.
Cured 3 days @ 77 deg plus or minus 3 deg F		5,000 psi min.	5,000 psi min.
*Cure test specimens so that peak exothermic temperature of resin does not exceed 100 degrees F.			
Note: See referenced specifications for preparation method of test specimens.			

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2.03 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 resin has cured.

2.04 WATER

- A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.05 SAMPLE BOTTLE

- A. 5-inch natural wide mouth HDPE bottle or 4-ounce clear PVC cylinder bottle; supplied with caps.

2.06 SOURCE QUALITY CONTROL

- A. Test Requirements: Perform tests for each batch of epoxy resin.
- B. Pot Life Test:
 - 1. Condition Component A and Component B to required temperature.
 - 2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
 - 3. Mix components for 60 seconds using non-metallic stirring instrument. Scrape sides and bottom of cup periodically.
 - 4. Probe mixture once with non-metallic stirring instrument every 30 seconds, starting 2 minutes prior to minimum specified pot life.
 - 5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.
- C. Slant Shear Test: Prepare specimens and perform tests in accordance with ASTM C882.

PART 3 EXECUTION

3.01 GENERAL

- A. Unless permitted otherwise, structurally repair cracks or joints listed below:
 - 1. Cracks considered to be defective as defined in Section 03 30 00, Cast-in-Place Concrete.

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- B. Do not proceed with injection work until submittals have been reviewed and approved by Engineer.
- C. Perform cracks or joints injection work after removing defective surface materials and after performing surface preparation, but prior to applying surface repair material unless otherwise noted. See Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces, and Section 03 01 33, Repair of Horizontal Concrete Surfaces, for concrete surface repair system.
- D. Width of cracks may vary along length and through thickness of concrete section.
- E. Remove all excess, unused epoxy resin materials on concrete surfaces exposed to view prior to end of Work.

3.02 EQUIPMENT

- A. Portable, positive displacement type pumps with in-line metering to meter and mix two epoxy resin components and inject mixture into cracks or joints.
- B. Pumps:
 - 1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
 - 2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
 - 3. Capable of immediate compensation for changes in resins.
 - 4. Do not use batch mix pumps.
- C. Discharge Pressure: Automatic pressure controls capable of discharging mixed epoxy resin at pressures in accordance with epoxy resin manufacturer's printed instruction and able to maintain pressure.
- D. Automatic Shutoff Control: Provide sensors on both Component A and Component B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.
- E. Proportioning Ratio Tolerance: Maintain epoxy resin manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 pounds per square inch.

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F. Ratio/Pressure Check Device:

1. Two independent valve nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.03 PREPARATION

- A. Free cracks or joints from loose matter, dirt, laitance, oil, grease, efflorescence, salt, and other contaminants.
- B. Clean cracks or joints in accordance with epoxy resin manufacturer's instructions.
- C. Clean surfaces adjacent to cracks or joints from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instruction by low pressure water cleaning using a pressure of 1,000 pounds per square inch to 3,000 pounds per square inch.
- D. Do not use acids and corrosives for cleaning, other than those specified herein unless neutralized prior to injecting epoxy resin.
- E. During installation and curing of materials, if ambient temperature is expected to drop below manufacturer's recommended minimum temperature, provide enclosures and heat as required.
- F. Provide work platforms as required.
- G. Dry out cracks or joints if required by manufacturer's instructions.

3.04 APPLICATION

- A. All liquid is to be removed from hydraulic structure prior to commencing with epoxy injection, unless approved otherwise.
- B. Entry Ports:
 1. Establish openings for epoxy resin entry in surface seal along crack.
 2. Determine space between entry ports equal to thickness of concrete member to allow epoxy resin to penetrate to the full thickness of the member.
 3. Drill injection holes at an angle between 45 degrees and 60 degrees from surface of concrete and perpendicular to alignment of cracks or joints, to intersect crack or joint at midpoint of concrete section, and

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intersect joints at midpoint between waterstop and interior or exterior concrete surface, except as noted otherwise.

4. Locate drill holes on alternate sides of crack or joint where possible, unless orientation of crack or joint is known or has been verified by non-destructive testing techniques or core drilling.
5. Drill Hole Spacing: Do not to exceed concrete thicknesses or 12 inches maximum, except as noted otherwise.
6. Adjust location and angle of drill holes to suit orientation of crack or joint and at commencement of drilling holes for injection and at beginning of each subsequent shift.
7. Take measures to prevent drilling holes for injection too shallow or too deep, or damaging existing waterstop in joints.
8. Remove dust and debris in drill holes and on surface of structure resulting from drilling operation, by flushing with water prior to installing the injection packers or ports.
9. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
 - a. Cracks or joints extend entirely through concrete element.
 - b. Backfill of walls on one side.
 - c. Slab-on-grade.
 - d. Difficult to excavate behind wall to seal both surfaces of crack.
10. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks and joints.

C. Application of Surface Seal along Cracks and Joints:

1. Apply surface seal in accordance with manufacturer's instructions to designated cracks and joints face prior to injection. Seal surface of cracks or joints to contain and prevent escape of injection epoxy.
2. Cure surface seal in accordance with manufacturer's printed instructions before commencing inject work.

D. Epoxy Injection:

1. Ensure zerk coupling is not installed in ports or packers next to the one being injected.
2. Start injection into each crack or joint at lowest elevation entry port or packer along vertical or diagonal crack or joint, and at one end of horizontal crack or joint.
3. Where injection entry ports or packers are used, continue injection at first port or packer until resin begins to flow out of port or packer at

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next highest elevation. Plug first port or packer and start injection at second port or packer until resin flows from next port or packer.

4. Inject entire crack or joint with same sequence.
5. At no time inject more than 6 feet length of first vertical crack or joint before verifying resin in sample bottle has start to set and cure.
6. Prior to commencing injection work along a horizontal crack or joint in structure when processed using ports or packers with zerk couplings are used, remove zerk couplings from injection ports or packers except for two ports or packers located where injection work will commence. Commence injection work in first two ports or packers. Once clean resin is vented from third injection port or packer, cease injection at first port or packer, and install zerk coupling and commence injection at third port or packer. Repeat process for fourth and subsequent ports or packers until full length of crack or joint has been injected.

E. Finishing:

1. Allow epoxy resin to cure in accordance with manufacturer's instruction after cracks or joints have been completely injected to allow surface seal removal without draining or runback of uncured epoxy resin material from cracks or joints.
2. Remove surface seal and injection packers or ports from cured injection resin along crack.
3. Finish crack or joint faces flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports, packers, drill holes, or damage from removal of surface seal is not acceptable.
5. Grind off protrusions and patch indentations and holes from injection packers and entry ports with a suitable patch material to satisfaction of Engineer.
6. Remove surplus surface seal material splatters and injection resin material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Epoxy Resin Two Component Ratio Tests:

1. Disconnect mixing head and pump two resin components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 pounds per square inch for both resin components.
3. Simultaneously discharge both resin components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.

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5. Complete test at 160 pounds per square inch discharge pressure and repeat procedure for 0 pounds per square inch 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 resin 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 pounds per square inch.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 pounds per square inch 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 stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Bottled Sample Tests:

1. During injection operation, provide at least one sample of mixed epoxy resin for each injection pump per shift per injection work day in a sample bottle.
2. Provide sufficient sample to demonstrate sample material epoxy resin will set and cure correctly.
3. Label each bottled sample with Contractor's name, date, and time sample was taken, and location in structure where sample was taken. Record details of bottle sample tests.
4. Place filled sample bottle upright in a container and allow sample to cure.
5. After sample has been allowed to cure, cut bottled sample open and visually inspect contents to verify that epoxy resin material has completely reacted and cured.

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6. Evaluation and Assessment of Test:
 - a. Should bottled sample(s) indicate a problem; such as epoxy resin not cured or foreign liquid in sample bottle, take verifying core sample immediately from cracks or joints, where material was used.
 - b. Should above-referenced bottle sample(s) and core sample(s) indicate a problem with epoxy resin, arrange to have a Technical Representative of the epoxy resin manufacturer come to Site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
 - c. Carry out further investigation work or corrective measures recommended by Technical Representative of epoxy resin manufacturer.

END OF SECTION

SECTION 03 64 24
POLYURETHANE INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. ASTM International (ASTM):
 - a. D638, Standard Test Method for Tensile Properties of Plastics.
 - b. D1622, Standard Test Method for Apparent Density of Rigid Cellular Plastics.
 - c. D1623, Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics.
 - d. D3574, Standard Test Method for Flexible Cellular Material Slab, Bonded, and Molded Urethane Foams.
 2. National Sanitation Foundation (NSF):
 - a. Standard 60, Standard for Drinking Water Treatment and Chemicals-Health Effects.
 - b. Standard 61, Standard for Drinking Water System Components-Health Effects.

1.02 DEFINITIONS

- A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.
- B. Injection: Method of bonding together; method of addressing or eliminating leakage through cracks or joints by installing polymer under pressure to fill the void in crack or joint.
- C. Joint: Planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements, and may contain embedded waterstops.
- D. Leak or Leakage: Crack or joint exhibiting moisture, sign of efflorescence, intermittent wet to touch, or continuous flow of liquid.
- E. Narrow Cracks: Width equal to or less than 0.015-inch.
- F. Wide Crack: Wider than 0.015-inch.

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1.03 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for polyurethane injection resin.
2. Technical data for metering, mixing, and injection equipment.
3. Submit:
 - a. Marked up drawings showing locations of proposed polyurethane injection work, including the following:
 - 1) Exact locations for injection.
 - 2) Depth of penetration or crack.
 - 3) Width of crack measured every 4 feet minimum.
 - 4) Length of penetration or crack.
 - b. Proposed materials.
 - c. Injection procedure, including the following:
 - 1) Preparation of penetration for polyurethane.
 - 2) Fittings for installation for injection.
 - 3) Temperature of installation.
 - 4) Measurement and monitoring of injection pressure.
 - 5) Surface cleaning and repair.
4. Sample bottle.

B. Informational Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for polyurethane resin injection.
2. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements. Certified test results for each batch of polyurethane.
3. Statements of Qualification for Polyurethane Resin Injection:
 - a. Manufacturer's Site representative.
 - b. Injection applicator.
 - c. Injection pump operating technician.
4. Sample of polyurethane resin mix ratio and injection pressure test records for concrete crack and joint injection work.
5. Installation instructions for repairing core holes with repair mortar.
6. Polyurethane resins injection pressure test records for concrete crack and joint injection work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staff:

1. Manufacturer's Site Representative:
 - a. Capable of instructing successful methods of polyurethane injection process for concrete structures.
 - 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 or certified by polyurethane resin manufacturer.
 - b. Minimum 3 years' experience in successful polyurethane injection.

1.05 PERFORMANCE REQUIREMENTS

- A. Injected polyurethane resin shall fill cracks, and in no case shall depth of penetration of injection material be less than 90 percent of full thickness of the concrete section for cracks.
- B. In cured state, injected polyurethane resin forms a dense rubber-like closed cell flexible foam compression gasket-type seal material.
- C. Notwithstanding the foregoing, injected cracks which exhibit leakage are considered deficient work irrespective of the depth of penetration observed in quality control core drilled samples. Reinject deficient work as required to meet the performance requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package adhesive material in new sealed containers and label with following information:
 - a. Manufacturer's name.
 - b. Product name and lot number.

- B. Storage and Protection: Store polyurethane resin material containers in accordance with manufacturer's printed instructions or in the absence of such information at ambient temperatures below 110 degrees F and above 68 degrees F.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Sika Corp., Lyndhurst, NJ; SikaFix HH Hydrophilic.
- B. Euclid Chemical Co., Cleveland, OH; DURAL Aqua-Fil.
- C. Prime Resins, Inc., Conyers, GA; Prime Flex 900 XLV.

2.02 POLYURETHANE RESIN

- A. Single-component, water-activated, hydrophilic polyurethane injection resin.
- B. Elongation: Minimum 350 percent, in accordance with ASTM D3574 or ASTM D638 test method.
- C. Tensile Strength: Minimum 150 psi, in accordance with ASTM D3574 or ASTM D638 test method.
- D. Shrinkage: Less than 2 percent.

2.03 SURFACE SEAL

- A. Provide seal with 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 resin has cured.

2.04 WATER

- A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.05 SAMPLE BOTTLE

- A. 5 inches natural wide mouth HDPE bottle or 4 ounces clear PVC cylinder bottle, supplied with caps.

2.06 SOURCE QUALITY CONTROL

- A. Test Requirements: Perform tests for each batch of polyurethane resins.

PART 3 EXECUTION

3.01 GENERAL

- A. Use of polyurethane injection shall be limited to locations as determined by Structural Engineer.
- B. Unless permitted otherwise, polyurethane inject cracks listed below:
 - 1. Cracks that leak.
 - 2. Cracks exhibit dampness, efflorescence, or other evidence of leakage.
- C. Do not proceed with injection work until action submittals have been reviewed and approved by the Structural Engineer of Record.
- D. Perform injection work after performing surface preparation.
- E. Width of the cracks shown may vary along the length and through the thickness of the concrete section.
- F. Remove all excess unused polyurethane resins materials inside the structure prior to the end of the work.

3.02 EQUIPMENT

- A. Portable, positive displacement type pumps with in-line metering to meter mixed components, and inject mixture into crack.
- B. Pumps: Positive displacement type pump.
- C. Discharge Pressure: Automatic pressure controls capable of discharging mixed polyurethane resin at pressures in accordance with polyurethane resin manufacturer's printed instructions, and able to maintain such pressure.
- D. Proportioning Ratio Tolerance: Maintain polyurethane manufacturer's prescribed mix ratio within a tolerance in accordance with polyurethane resin manufacturer's printed instructions.
- E. Pressure gauge capable of sensing pressure behind valve.

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3.03 PREPARATION

- A. Free cracks from loose matter, dirt, laitance, oil, grease, salt, and other contaminants.
- B. Clean cracks in accordance with polyurethane resins manufacturer's printed instructions.
- C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, encrustation, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks in accordance with manufacturer's printed instructions.
- D. Do not use acids and corrosives for cleaning, other than those specified herein, unless neutralized prior to injecting polyurethane resin.
- E. During installation and curing of materials, if the ambient temperature is expected to drop below the manufacturer's recommended minimum temperature, provide enclosures and heat as required.
- F. Provide work platforms as required.

3.04 APPLICATION

- A. Injection Ports:
 - 1. Drill holes shall be installed along cracks designated for injection as required to meet the performance requirements for injection.
 - 2. The requirements for installing drill holes for injection provided below represent acceptable minimum standards of practice.
 - 3. Drill holes for injection at an angle between 45 degrees and 60 degrees from the surface of the concrete and perpendicular to the cracks alignment, to intersect the cracks at the midpoint of the concrete section, except as noted otherwise.
 - 4. Locate drill holes on alternate sides of the crack where possible, unless orientation of the crack is known or has been verified by nondestructive testing techniques or core drilling.
 - 5. The spacing of drill holes not to exceed the concrete thickness or 12 inches (maximum), except as noted otherwise.
 - 6. Adjust location and angle of drill holes to suit orientation of crack and at required angle, such as using a template, during the Work especially at the commencement of drilling holes for injection and at the beginning of each subsequent shift.

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7. Take measures to prevent drilling holes for injection too shallow, or too deep. Shallow hole injections lead to concrete spalls. Repair spalls at Contractor's expense.
8. Remove dust and debris in drill holes and on interior surface of the structure resulting from drilling operation, by flushing with water prior to installing injection packers or ports.
9. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling, or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks and joints.

B. Application of Surface Seal Along Cracks:

1. Apply surface seal along the length of the cracks designated for injection on the top side and underside of slabs, or both sides of walls, where possible in order to contain, confine, and prevent escape of the injected polyurethane resin, in accordance with manufacturer's printed instructions.
2. Cure the surface seal in accordance with the material's manufacturer's printed instructions.

C. Polyurethane Injection of Cracks:

1. Inject polyurethane resins, mixed with accelerator or in a neat form, into cracks in a sequential manner, and reinjection as required, to meet the performance requirements.
2. Start injection into each crack at lowest elevation entry port for vertical or diagonal cracks and at one end for horizontal cracks in vertical structure. Continue injection at first port until pure uncontaminated resin begins to flow out of next port. Plug first port and start injection at second port until polyurethane resin flows from next port. Inject crack in a sequential manner until the full length of the crack has been injected. At no time inject more than 6 feet length of vertical crack before verifying that the first 12 inches of injected crack is set and cured.
3. Prior to commencing the injection work along a crack in horizontal structure when packers with zerk couplings are used, remove the zerk couplings from the injection packers or ports except for the two packers located where the injection work will commence. Commence injection work in the first two packers. Once clean resin is vented from the third injection packer, cease injection at the first packer, and install the zerk coupling and commence injection at the third packer. Repeat the process for the fourth and subsequent packers until the full length of the crack has been injected.

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D. Finishing:

1. Cure polyurethane resins after crack has been completely filled without draining or runback of polyurethane resin material from crack.
2. Remove surface seal and injection packers or ports from along the crack.
3. Finish surface flush and to match surrounding concrete.
4. Indentations or protrusions caused by placement of entry ports drill holes, or damage from removal of surface seal, is not acceptable.
5. Grind off protrusions, and patch indentations and holes from packers and ports with a suitable patch material to the satisfaction of the Engineer.
6. Remove surplus surface seal material on splatters and injection material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect polyurethane component delivery line 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 pounds per square inch.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 pounds per square inch 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 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

B. Bottled Samples:

1. During the injection operation, provide at least one sample of the mixed polyurethane injection resins per shift per injection pump in a sample bottle.

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2. Half fill each sample bottle, containing a small amount of water (5 percent by volume) with polyurethane injection resin material from the pump discharge hose. Swirl or lightly shake sample to thoroughly mix resin with the water. When foaming rises near the top of the bottle, install the cap to contain the expanding resin material.
3. Label each bottled sample with Contractor's name, date and time sample was taken, and location in structure where sample was taken. Maintain a log of bottle samples.
4. Place filled sample bottle upright in a box or pail and allow sample to cure.
5. After sample cured, cut bottled sample open and visually inspect contents to verify that polyurethane injection resins material has completely reacted and cured.
6. Evaluation and Assessment of Test:
 - a. If a bottled sample(s) indicates a problem with the polyurethane injection resins, such as polyurethane resin not cured; take verifying core sample immediately from the cracks, where the material was used.
 - b. If the above-referenced bottle sample(s) and core sample(s) indicate a problem with the polyurethane injection resins, have a Technical Representative of the polyurethane injection resins manufacturer come to site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
 - c. Carry out further investigation work or corrective measures recommended by the Technical Representative of the polyurethane injection resins manufacturer.

C. Visual Inspection:

1. Confirm injection of polyurethane has stopped the leaking material.
2. Confirm installation of material is in accordance with manufacturers' requirements.
3. Confirm installation of material is not damaging concrete.

END OF SECTION

SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 DEFINITIONS

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

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

1.03 SUBMITTALS

A. Action Submittals:

- 1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

- 1. Concrete Anchors:
 - a. Manufacturer's product description and installation instructions.
 - b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
 - c. Adhesive Anchor Installer Certification.
- 2. Passivation method for stainless steel members.

1.04 QUALITY ASSURANCE

A. Qualifications:

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

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1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package stainless steel items in a manner to provide protection from carbon impregnation.
- B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

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

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8 A193/A193M, Grade B7
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

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

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.

B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
 - b. DeWalt/Powers Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).

C. Self-Tapping Concrete Screw Anchors:

1. Manufacturers and Products:
 - a. DeWalt/Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
 - b. DeWalt/Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
 - c. DeWalt/Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
 - d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
 - e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).

D. Adhesive Anchors:

1. Threaded Rod:
 - a. Diameter as shown on the Drawings.
 - b. Length as required to provide minimum depth of embedment indicated and thread projection required.
 - c. Clean and free of grease, oil, or other deleterious material.

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2. Adhesive:
 - a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
 - b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
3. Packaging and Storage:
 - a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
 - b. Store adhesive on pallets or shelving in a covered storage area.
 - c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
 - d. Dispose of When:
 - 1) Shelf life has expired.
 - 2) Stored other than in accordance with manufacturer's instructions.
4. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 (ESR-3187).
 - b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508), or AT-XP Adhesive Anchors (IAPMO UES-263).
 - c. DeWalt/Powers Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

E. Adhesive Threaded Inserts:

1. Type 316 stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.

2.03 POST-INSTALLED MASONRY ANCHORS

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

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2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU.
3. DeWalt/Powers Fasteners, Brewster NY; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Wedgebolt+ (ESR-1678) for grout-filled masonry.

PART 3 EXECUTION

3.01 CONCRETE ANCHORS

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

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- I. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without Engineer's prior approval unless specifically shown on the Drawings.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

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

3.03 MANUFACTURER'S SERVICES

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

3.04 FASTENER SCHEDULE

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

Service Use and Location	Product	Remarks
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application

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Service Use and Location	Product	Remarks
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
2. All Others		
All service uses and locations	Stainless steel fasteners	

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

END OF SECTION

SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

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

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2. Verification Inspector: CWI who acts on behalf of the Owner. This type of independent inspection and testing is the prerogative of the Owner, who may perform this function, or waive independent verification inspection if it is not required by the building official and building code.
- C. MT: Magnetic Particle Testing.
- D. NDE: Nondestructive Examination.
- E. NDT: Nondestructive Testing.
- F. PJP: Partial Joint Penetration.
- G. PQR: Procedure Qualification Record.
- H. PT: Liquid Penetrant Testing.
- I. RT: Radiographic Testing.
- J. Special Inspection: Non-destructive examination exclusive of VT. Special inspection includes NDE such as MT, PT, UT, RT, and Verification Inspection. Special Inspection personnel report to, and are retained by Owner. See additional requirements in Section 01 45 33, Special Inspection, Observation, and Testing.
- K. UT: Ultrasonic Testing.
- L. VT: Visual Inspection/Testing.
- M. WPQ: Welder/Welding Operator Performance Qualification Record.
- N. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

- A. Action Submittals:
 1. Shop Drawings:
 - a. Shop and field WPSs and PQRs.
 - b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.

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- c. Welding Data (Shop and Field): Submit welding data together with the Shop Drawings as a complete package.
 - 1) Show on the Shop Drawings, or on a weld map, complete information regarding base metal specification designation, location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tails of combined welding and NDE symbols as indicated in AWS A2.4.
 - 2) Clearly distinguish between shop and field welds.
 - 3) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
 - 4) Welding and NDE Symbols: In accordance with AWS A2.4.
 - 5) Welding Terms and Definitions: In accordance with AWS A3.0.

B. Informational Submittals:

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

1.04 QUALIFICATIONS

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

1.05 SEQUENCING AND SCHEDULING

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

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

- A. Contractor's CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:
 - 1. Verifying conformance of specified job material and proper storage.
 - 2. Monitoring conformance with approved WPS.
 - 3. Monitoring conformance of WPQ.
 - 4. Inspecting weld joint fit-up and performing in-process inspection.
 - 5. Providing 100 percent visual inspection of welds.
 - 6. Coordinating with nondestructive testing personnel and reviewing NDE test results.
 - 7. Maintaining records and preparing reports documenting that results of CWI VT and subsequent NDE testing comply with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

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

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

- A. Quality Control Inspection:
 - 1. All Welds: 100 percent VT by Contractor's CWI.
 - 2. Acceptance Criteria:
 - a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 10.24.
 - b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - c. Stud Connections: AWS D1.1/D1.1M, Paragraph 9.8.1.

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B. Nondestructive Testing Requirements:

1. NDT frequency shall be as specified below, as required by referenced welding codes, or as specified in the attached table. In case there is a conflict, the higher frequency level of NDT shall apply.
 - a. Nontubular Connections:
 - 1) CJP Butt Joint Groove Welds: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.
 - 2) All Other CJP Groove Welds: 10 percent random UT.
 - 3) Fillet Welds and PJP Groove Welds: 0 percent random PT or MT.
 - b. Tubular Connections:
 - 1) CJP Butt Joint Groove Welds Made from One Side without Backing: 100 percent RT or UT in accordance with AWS D1.1/D1.1M, Paragraph 10.25.2 requirements.
 - 2) CJP Butt Joint Groove Welds Made without Backing or Back-gouging: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.
 - 3) All Other CJP Groove Welds: 10 percent random UT.
 - 4) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
2. NDT Procedures and Acceptance Criteria:
 - a. Nontubular Connections:
 - 1) RT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part E. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.12.1.
 - 2) UT: Perform in accordance with AWS D1.1/D1.1M, Clause 86, Part F. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.13.1.
 - 3) PT and MT:
 - a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
 - b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - b. Tubular Connections:
 - 1) RT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.27, and Paragraph 10.28.
 - 2) UT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.26.

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- 3) PT and MT:
 - a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
 - b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 10.24.

3.03 FIELD QUALITY CONTROL

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

3.04 WELD DEFECT REPAIR

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

3.05 SUPPLEMENT

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

END OF SECTION

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WELDING AND NONDESTRUCTIVE TESTING						
Specification Section	Governing Welding Codes or Standards	Submit WPS	Submit WPQ	Onsite CWI Req'd	Submit Written NDT Procedure Specifications	NDT Requirements
03 21 00 Steel Reinforcement	AWS D1.4/D1.4M, Structural Welding Code - Reinforcing Steel	Yes	Yes	Yes	Yes	100% VT and 100% MT of all rebar splices; also see Section 03 21 00
05 12 00 Structural Steel Framing	AWS D1.1/D1.1M, Structural Welding Code – Steel	Yes	Yes	Yes	Yes	100% VT and 10% UT or RT of all groove-and-butt joint welds; 10% MT of all fillet welds; also see Section 05 12 00
05 31 00 Steel Decking	AWS D1.1/D1.1M, Structural Welding Code – Steel or AWS D1.3/D1.3M, Structural Welding Code – Sheet Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 31 00
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum or AWS D1.6/D1.6M, Structural Welding Code - Stainless Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 50 00
05 53 00 Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 53 00
33 05 01.01 Welded Steel Pipe and Fittings	ASME BPV Code, Section IX; and AWS D1.1/D1.1M, Structural Welding Code - Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 33 05 01.01

SECTION 05 12 00
STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Galvanizers Association (AGA): Quality Assurance Manual.
 2. American Institute of Steel Construction (AISC):
 - a. 207, Standard for Certification Programs.
 - b. 303, Code of Standard Practices for Steel Buildings and Bridges.
 - c. 325, Steel Construction Manual.
 - d. 326, Detailing for Steel Construction.
 - e. 341, Seismic Provisions for Structural Steel Buildings.
 - f. 360, Specification for Structural Steel Buildings.
 - g. 420, Certification Standard for Shop Application of Complex Protective Coating Systems.
 3. American Welding Society (AWS):
 - a. D1.1/D1.1M, Structural Welding Code—Steel.
 - b. D1.8/D1.8M, Structural Welding Code—Seismic Supplement.
 4. ASTM International (ASTM):
 - a. A6/A6M, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 - b. A36/A36M, Standard Specification for Carbon Structural Steel.
 - c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - d. A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - e. A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
 - f. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - g. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
 - h. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
 - i. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

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- j. A563, Standard Specification for Carbons and Alloy Steel Nuts.
- k. A572/A572M, Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel.
- l. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- m. A992/A992M, Standard Specification for Structural Steel Shapes.
- n. A1065/1065M, Standard Specification for Cold-Formed Electric Fusion (Arc) Welded High-Strength Low-Allow Structural Tubing in Shapes with 50 ksi [345 MPa] Minimum Yield Point.
- o. A1085/A1085M, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
- p. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
- q. D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting.
- r. D7803, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating.
- s. F436, Standard Specification for Hardened Steel Washers.
- t. F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
- u. F1136, Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners.
- v. F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.
- w. F3148, Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144 ksi Minimum Tensile Strength, Inch Dimensions.
- 5. Occupational Safety and Health Administration (OSHA).
- 6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Provide Shop Drawing details showing:
 - a. Erection plans.
 - b. Members, including piece numbers, sizes, grades, dimensions, cambers, and connection details.
 - c. Anchor bolt layouts.

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- d. Hardened washer details.
 - e. Connection material specifications.
 - f. Indicate type, size, and length of bolts.
 - g. Joint details for partial and complete penetration welds.
 - h. Indicate welds by standard AWS symbols, distinguishing between shop and field welds and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - i. Indicate members and connection elements being reused or left unmodified from the existing structure.
- 2. Product specifications, including primer and other coatings.
 - 3. Identify pretensioned and slip-critical high strength bolted connections.
 - 4. Weld access hole dimensions, surface profile, and finish requirements.
 - 5. Nondestructive testing (NDT) where performed by the fabricator.
 - 6. Welding requirements as specified in AISC 341 Appendix W, Section W2.2 or AWS D1.8/D1.8M.

B. Informational Submittals:

- 1. Name and address of manufacturer(s).
- 2. Mill Certificates of tests made in accordance with ASTM A6/A6M.
- 3. Manufacturers' testing procedures and standards.
- 4. Preparation and installation or application instructions, as appropriate.
- 5. Proposed method to resolve misalignment between anchor bolts and bolt holes in steel members.
- 6. High-Strength Bolts:
 - a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that products meet specified chemical and mechanical requirements.
 - b. Manufacturer's inspection test report results for production lot(s) furnished to include:
 - 1) Tensile strength.
 - 2) Yield strength.
 - 3) Reduction of area.
 - 4) Elongation and hardness.
 - c. Certified Mill Test Reports for Bolts and Nuts:
 - 1) Name and address of manufacturer.
 - 2) Bolts correctly marked.
 - 3) Marked bolts and nuts used in required mill tests and manufacturer's inspection tests.
- 7. Direct Tension Indicators (DTIs): Manufacturer's test report meeting requirements of ASTM F959.

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8. Twist-Off-Type Tension-Control (TC) Bolts: Manufacturer's test report meeting requirements of ASTM F3125 Grade F1852 or ASTM F3125 Grade F2280.
9. Welding Procedures, Qualifications, and Inspection Reports: As specified in Section 05 05 23, Welding.
10. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.
11. AISC Quality Certification: AISC certificate showing name and address of certified firm, effective date, and category of certification; or, for erectors, documentation of similar project experience to include project name, location, date of completion, and name and phone number of owner's contact person.
12. Nondestructive Testing (NDT) report.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Welding qualifications as specified in Section 05 05 23, Welding.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of AGA's Quality Assurance Manual.

B. Certifications:

1. Mill identification marks, heat number, size of section, and length in accordance with ASTM A6/A6M.
2. AISC Quality Certification for Fabricator: A fabricator who participates in the AISC Certification program and is designated an AISC Building Fabricator.

1.04 DELIVERY, STORAGE, AND HANDLING

- #### A. Delivery:
- Load structural members in such a manner that they will be transported and unloaded without damage to coatings and without being excessively stressed, deformed, or otherwise damaged.

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B. Storage:

1. Store materials to permit easy access for inspection and identification. Store in a dry area and keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 - a. Do not store materials in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials as directed.
2. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 - a. Fasteners may be repackaged provided testing and inspecting agency observes repackaging and sealing of containers.
 - b. Clean and lubricate bolts and nuts that become dry or rusty before use.
 - c. Comply with manufacturer's written recommendations for cleaning and lubricating fasteners and for retesting fasteners after lubrication.

- C. Handle materials to avoid distortion or damage to members or supporting structures.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Rolled Plates, Shapes except W-Shapes and Bars: ASTM A572/A572M Grade 50 or A36/A36M, unless indicated otherwise.
- B. W-Shapes: ASTM A992/A992M, unless indicated otherwise on the Drawings.
- C. Steel Pipe: ASTM A53/A53M, Grade B.
- D. Round Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 46 ksi) or ASTM A1085/A1085M.
- E. Square and Rectangular Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 50 ksi) or ASTM A1085/A1085M.
- F. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon, such as plates over 1.5 inches thick for ASTM A36/A36M and ASTM A572/A572M steels, limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

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2.02 FASTENERS

- A. Anchor Bolts: As specified in Section 05 50 00, Metal Fabrications.
- B. Post-Installed Anchors: As specified in Section 05 05 19, Post-Installed Anchors.
- C. High-Strength Bolts:
 - 1. ASTM F3125 Grade A325, Type 1, or Grade A490, bolt Type 1.
 - 2. Bolt Length and Thread Length: As required for connection type shown, with hardened washers as required.
- D. Direct Tension Indicators (DTIs) or Load Indicator Washers:
 - 1. ASTM F959, coating type to match bolt finish.
 - 2. Type A325 or Type A490, to match bolt grade.
 - 3. Manufacturers and Products:
 - a. TurnaSure LLC, Langhorne, PA; DTIs.
 - b. Applied Bolting Technology Products, Ludlow, VT; DTIs, regular or Squirter type.
- E. Twist-Off-Type Tension-Control (TC) Bolts:
 - 1. High-strength, ASTM F3125 Grade F1852, bolt Type 1, mechanically galvanized.
 - 2. Manufacturers:
 - a. LeJeune Bolt Company, Burnsville, MN.
 - b. Nucor Fastener, Saint Joe, IN.
 - c. Haydon Bolts, Philadelphia, PA.
 - d. Vermont Fasteners Manufacturing, Swanton, VT.
- F. Nuts: ASTM A563, type to match bolt type and finish.
- G. Hardened Steel Flat and Beveled Washers: ASTM F436, type to match bolt finish.
- H. Stud Shear Connectors: As specified in Section 05 50 00, Metal Fabrications.

2.03 ANCILLARY MATERIALS

- A. Surface Preparation and Primer: As specified in Section 09 90 00, Painting and Coating.
- B. Grout: As specified in Section 03 62 00, Grouting.

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2.04 FABRICATION

A. General:

1. Fabricate as shown and in accordance with AISC 360 and AISC 303.
2. Columns: Full-length members without splices, unless shown otherwise or approved by Engineer.
3. Mark and match mark materials for field assembly.
4. Complete assembly, including bolting and welding of units, before start of finishing operations.
5. Fabricate to agree with field measurements.
6. Fabricate beams with rolling camber up.
7. Fillet re-entrant cuts and corners to radius of not less than 1/2-inch.
8. Sheared and flame-cut edges shall be free from rough corners and projections.

B. Connections:

1. Shop Connections: Weld or bolt as shown on the Drawings.
2. Meet requirements of AISC 325 for bolted double-angle shear connections, unless indicated otherwise.
3. Meet OSHA requirements for one independent bolt at beams framing into column web connections.
4. Provide oversized holes for anchor bolts in column baseplate in accordance with AISC 325, unless indicated otherwise.

C. Welded Construction:

1. As specified in Section 05 05 23, Welding.
2. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

D. Interface with Other Work:

1. Holes:
 - a. As necessary or as indicated for securing other Work to structural steel framing, and for passage of other Work through steel framing members shall be approved by Engineer.
 - b. No flame-cut holes are permitted without prior approval of Engineer.
2. Weld threaded nuts to framing members, and other specialty items to receive other Work.

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2.05 FINISHES

A. Shop Paint Primer:

1. Surface Preparation and painting as specified in Section 09 90 00, Painting and Coating.
2. Do not shop prime the following surfaces, unless indicated otherwise:
 - a. Within 2 inches of field-welded connections.
 - b. Steel members to be completely encased in reinforced concrete or coated with cementitious fireproofing.
 - c. Faying surfaces of slip critical bolted connections and bolted connections in Seismic Force Resisting Systems.
3. Apply shop primer to top flange surfaces of composite steel beams, unless indicated otherwise.

B. Slip Critical Bolted Connections:

1. Coated Faying Surfaces: Coat faying surfaces of slip critical bolted connections specified or shown with a paint primer with a Class A or Class B coating in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts and as specified in Section 09 90 00, Painting and Coating. Protect against overspray by use of masking. Remove inadvertent overspray from the faying surfaces.
2. Galvanized Faying Surfaces: Prepare as required for Class A faying surface.

2.06 SOURCE QUALITY CONTROL

A. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test fabrication welds as specified in Section 05 05 23, Welding.
2. Visually inspect fabrication welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. An independent testing agency will be retained by Owner to perform the inspection and testing of fabrication welds as specified in Section 05 05 23, Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Welding.

B. Special inspection of fabrication process and shop welding will be provided by Owner as indicated on the Drawings.

PART 3 EXECUTION

3.01 ERECTION

A. General:

1. Meet requirements of AISC 360 and AISC 303, with exceptions as specified.
2. Install Contractor-designed temporary construction bracing to provide necessary support until components are in place and construction is complete.
3. Provide additional field connection material as required by AISC 303.
4. Splice members only where indicated and accepted on the Shop Drawings.

B. Field Assembly:

1. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly.
2. Set structural frames accurately to lines and elevations shown.
3. Align and adjust various members forming a part of a complete frame or structure before permanently fastening.
4. Level and plumb individual members of structure within tolerances shown in AISC 303.
5. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be completed and in service.
6. Perform necessary adjustments to compensate for minor discrepancies in elevations and alignment.

C. Setting Baseplates and Bearing Plates:

1. Clean concrete and masonry bearing surfaces of bond reducing materials and roughen to improve bond to surfaces.
2. Clean bottom surface of baseplates and bearing plates.
3. Set loose and attached baseplates and bearing plates for structural members on wedges, shims, leveling nuts, or other adjustable devices. Use leveling plates where indicated.
4. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to placing grout. Weld plate washer to baseplate where indicated.
5. Grout Under Baseplate: As specified in Section 03 62 00, Grouting, prior to placing loads on structure.

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D. Anchor Bolts:

1. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in-place work.
2. Provide templates and other devices for presetting bolts and other anchors to accurate locations.
3. Projection of anchor bolts beyond face of concrete and threaded length shall be adequate to allow for full engagement of threads of hold-down nuts, adjustment of leveling nuts, washer thicknesses, and construction tolerances, unless indicated otherwise.
4. Placement Tolerances:
 - a. As required by AISC 303, unless indicated otherwise.
 - b. Embedded anchor bolts shall not vary from dimensions shown on the Drawings by more than the following:
 - 1) Center-to-Center of Any Two Bolts Within an Anchor Group: 1/8-inch.
 - 2) Center-to-Center of Adjacent Anchor Bolt Groups: 1/4-inch.
 - 3) Variation from Perpendicular to Theoretical Bearing Surface: 1:50.

E. Connections:

1. High-Strength Bolted:
 - a. Tighten in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
 - b. Pretension all bolts unless noted otherwise on the Drawings.
 - c. Hardened Washers:
 - 1) Provide at locations required by Washer Requirements section of RCSC Specification for Structural Joints Using High Strength Bolts, to include pretensioned and slip critical connections using slotted or oversized holes or F3125 Grade A490 bolts.
 - 2) Use beveled style and extra thickness where required by RCSC Specification.
 - 3) Use square or rectangular beveled washers at inner flange surfaces of American Standard beams and channels.
 - 4) Do not substitute DTIs for hardened flat washers required at slotted and oversize holes.
 - d. For snug-tightened connections (N, X), tighten to snug tight condition. Use hardened washer over slotted or oversize holes in outer plies.

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2. Pretensioned Bolted:
 - a. Use DTIs or twist-off-type tension-control (TC) bolts at slip critical (SC) and pretensioned bearing-type connections.
 - b. DTIs:
 - 1) Position within bolted assembly in accordance with ASTM F959.
 - 2) Install bolts, with DTIs plus hardened washers as required, in holes of assembly and tighten until plies are in firm contact and fasteners are uniformly snug tight.
 - c. Final tightening bolts begin at most rigid part of bolted connection and progress toward free edges until final twist-off-type tension-control (TC) bolts or until DTIs have been compressed to an average gap equal to or less than shown in ASTM F959, Table 2.
3. Welded:
 - a. As specified in Section 05 05 23, Welding.
 - b. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

3.02 MISFITS

A. At Bolted Connections:

1. Immediately notify Engineer for approval of one of the following methods of correction:
 - a. Ream holes that must be enlarged to admit bolts and use oversized bolts.
 - b. Plug weld misaligned holes and redrill holes to admit standard size bolts.
 - c. Drill additional holes in connection, conforming to AISC for bolt spacing and end and edge distances, and add additional bolts.
 - d. Reject member containing misfit, incorrect sized, or misaligned holes and fabricate new member to ensure proper fit.
2. Do not enlarge incorrectly sized or misaligned holes in members by burning or by use of drift pins.

B. At Anchor Bolts:

1. Resolve misalignments between anchor bolts and bolt holes in steel members in accordance with approved Shop Drawing.
2. Do not flame cut to enlarge holes without prior approval of Engineer.

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C. Gas Cutting:

1. Do not use gas cutting torches in field for correcting fabrication errors in structural framing.
2. Secondary members not under stress and concealed in finished structure may be corrected by gas cutting torches, if approved by Engineer.
3. Finish flame-cut sections equivalent to sheared and punched appearance.

3.03 REPAIR AND CLEANING

- A. Clean shop primer from field welds, bolted connections, and abraded areas immediately after erection.
- B. Remove and grind smooth tack welds, fit-up-lugs, and weld runoff tabs.
- C. Remove weld back-up bars and grind smooth where indicated on the Drawings.
- D. Apply touchup paint primer by brush or spray of same thickness and material as that used in shop application and as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD FINISH

- A. Field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

- A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.
- B. Contractor-Furnished Quality Control: Inspect and test as required in Section 01 45 16.13, Contractor Quality Control.
- C. High-Strength Bolted Connections:
 1. An independent testing agency will be retained by Owner to perform the following inspection and testing in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts:
 - a. Marking identification and conformance to ASTM standards.
 - b. Alignment of bolt holes.

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- c. Placement, type, and thickness of hardened washers.
 - d. Tightening of bolts.
 - 2. Snug-Tightened Connections (N, X): Snug tight condition with plies of joint in firm contact.
 - 3. Pretensioned Bearing and Slip Critical (SC) Connections:
 - a. Conduct preinstallation test.
 - b. Monitor installation and tightening of DTIs or TC bolts.
 - c. Monitor condition of faying surfaces for slip critical connections.
 - 4. Preinstallation Test:
 - a. Conduct test in accordance with Specification for Structural Joints Using ASTM F3125 Grade A325 or Grade A490 bolts prior to using bolt tension measuring device.
 - b. Select representative sample of not less than three bolts of each diameter, length, and grade.
 - c. Include DTIs and flat hardened washers as required to match actual connection assembly.
 - 5. Nondestructive Testing (NDT): Inspect bolted connections and perform corrections as required to meet code acceptance criteria per RCSC Specification for Structural Joints Using High-Strength Bolts.
 - 6. Defective Connections: Correct and reinspect defective and improperly tightened high-strength bolted connections. Retest pretensioned bolts as necessary to demonstrate compliance of completed work.
- D. Welding:
- 1. Contractor's Certified Welding Inspector (CWI): Inspect and test field welds as specified in Section 05 05 23, Welding.
 - 2. Visually inspect field welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
 - 3. An independent testing agency will be retained by Owner to perform inspection and testing of field welds as specified in Section 05 05 23, Welding.
 - 4. Repair and retest defective welds as specified in Section 05 05 23, Welding.
- E. Special inspection will be provided by Owner as indicated on the Drawings.

END OF SECTION

SECTION 05 31 00
STEEL DECKING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Iron and Steel Institute (AISI): Specifications for the Design of Cold Formed Steel Structural Members.
 2. American Welding Society (AWS): D1.3, Structural Welding Code-Sheet Steel.
 3. ASTM International (ASTM):
 - a. A611, Standard Specification for Structural Steel (SS), Sheet, Carbon, Cold-Rolled.
 - b. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - c. A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - d. A924, Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
 4. Steel Deck Institute (SDI):
 - a. Design Manual for Composite Decks, Form Decks and Roof Decks.
 - b. Diaphragm Design Manual.
 5. Factory Mutual (FM):
 - a. Factory Mutual Approval Guide.
 - b. FM Research Corporation (FMRC): Approval Requirements for Steel Roof Deck Construction.
 6. International Code Council Evaluation Service, Inc. (ICC-ES): Evaluation Reports for Deck Fasteners.
 7. UL: Fire Resistance Directory.

1.02 SUBMITTALS

- A. Action Submittals:
1. Plan view layout of decking showing type and section properties of deck panels, reinforcing channels, pans, special jointing, and accessories.
 2. Location of openings, deck laps, and deck attachment details.

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B. Informational Submittals:

1. Decking manufacturer's installation requirements.
2. Welding Procedures, Qualifications, and Inspection Report: As specified in Section 05 05 23, Welding.
3. Operation manuals for mechanical fastener installation tools.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 QUALITY ASSURANCE

A. General: For metal decking section properties, meet requirements of AISI Specifications for Design of Cold-Formed Steel Structural Members.

B. FM Requirements:

1. Steel Roof Deck: Listed in Factory Mutual "Approval Guide" for Class 1 fire rating and Class 1-90 wind uplift rating.
2. Mechanical Fasteners: Packing containers shall show name of manufacturer and product and FMRC approval mark.

C. Qualifications for Field Welding: As specified in Section 05 05 23, Welding.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.
- B. Store deck bundles on platforms or pallets, with one end elevated to provide drainage.
- C. Protect bundles against condensation with a ventilated waterproof covering.
- D. Stack bundles so there is no danger of tipping, sliding, rolling, shifting or material damage.

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PART 2 PRODUCTS

2.01 METAL DECKING

- A. Provide metal deck as shown in the following schedule:

STEEL DECK SCHEDULE								
Type	Depth (in)	Panel Width (in)	Design Thickness (gauge)	Min. Yield Strength Fy (ksi)	Min. (+) S (in ³ /ft)	Min. I (in ⁴ /ft)	Minimum Diaphragm Shear Capacity (lbs/ft)	Finish
Roof Deck	1-1/2	36	18	33	0.322	0.302	600	Galv, G-90

- B. Materials and Finishes:

1. Galvanized Deck:
 - a. Sheet steel for galvanized deck and accessories shall conform to ASTM A653 Structural Quality Grade 33 or higher, as shown in Steel Deck Schedule.
 - b. Galvanizing shall conform to ASTM A924 with coating class of G90 as defined in ASTM A653 and as shown in Steel Deck Schedule.

- C. Manufacturers:

1. Vulcraft Division of Nucor Co., Brigham City, UT.
2. BHP Steel Building Products, USA, Inc., West Sacramento, CA.
3. Verco Manufacturing, Inc., Phoenix, AZ.
4. United Steel Deck, Inc., Summit, NJ.

2.02 ACCESSORIES

- A. Provide pour stops, column closures, end closures, cover plates, girder fillers, ridge and valley plates, finish strips, reinforcing channels, and other accessories as required for complete installation.
- B. Accessories shall be minimum 22-gauge, except edge forms shall be sized as required by the deck manufacturer, unless shown otherwise on the Drawings.

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2.03 MECHANICAL FASTENERS

A. Self-Drilling Screws:

1. Self-drilling, self-tapping screws with hexagonal washer head and corrosion-resistant finish.
2. Manufacturers and Products:
 - a. ITW Buildex, Itasca, IL; ICH Traxx Self-Drilling Fasteners with Climaseal Coating and Autotraxx Standup Installation Tool.
 - b. Hilti, Inc., Tulsa, OK; Kwik-Pro HWH Self-Drilling Screws with Kwik-Cote Treatment and Kwik-Tapper Screwdriver.

B. Powder Driven Fasteners:

1. Knurled shank, minimum 1/2-inch diameter steel washer, corrosion-resistant coating.
2. Pin diameter and length to suit deck type and flange thickness of steel support member.
3. Manufacturers and Products:
 - a. ITW Buildex, Itasca, IL; Buildex BX14 pins with yellow dichromate galvanizing and BX900 Installation Tool.
 - b. Hilti, Inc., Tulsa, OK; ENP-series fasteners with electroplated zinc coating and DX-750 Installation Tool.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine supporting framing and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of steel deck.

3.02 INSTALLATION

- A. Locate deck bundles to prevent overloading of support framing members.
- B. Install at right angles to supporting members in a three span minimum lay-up, unless shown otherwise, and in accordance with Specification and manufacturer's installation recommendation.
- C. Bearing: 1-1/2 inches, minimum.
- D. Endlaps: Minimum of 2 inches and located over supports.
- E. Do not stretch sidelaps.

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F. Closure Plates:

1. Install closure and cover plate accessories as recommended by the metal deck manufacturer, unless shown otherwise on the Drawings.
2. Floor Deck and Form Deck Closures:
 - a. Fasten column closures, cell closures, and zee closures to deck to provide tight fitting closures at open ends of ribs and sides of decking.
 - b. Fasten cell closures at changes of direction of deck units unless otherwise indicated.

G. Holes and Openings

1. Cut and fit around roof openings and other work projecting through or adjacent to decking.
2. Locate holes and openings as shown to clear structural framing and bracing members.
3. Reinforcement around openings:
 - a. Roof Deck: For hole sizes of at least 6 inches across, but not more than 12 inches across in roof deck, reinforce with 0.0474-inch design thickness steel plate, painted or galvanized to match deck coating. Extend plate at least 12 inches beyond opening in all directions and attach to top of roof deck with No. 10 self-drilling screws at 6-inch spacing and at all corners. For openings larger than 12 inches across, reinforce roof deck with framing as shown on the Drawings.

H. Protect deck areas from heavy concentrated loads or wheel traffic with planking or other approved means.

I. Completed Deck: Free from buckles and irregularities, and in accordance with FM and UL requirements.

SALMON CREEK TREATMENT PLANT
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3.03 DECK ATTACHMENT

A. Fasten panels as shown in the following schedule:

STEEL DECK ATTACHMENT SCHEDULE							
		At Perpendicular Supports		At Parallel Supports		At Sidelaps	
Type	Depth (in.)	Type	No. Per Sheet	Type	Spacing (in.)	Type	Spacing
Roof Deck	1-1/2	Power driven fasteners	7	Power driven fasteners	12	#10 Self-drilling screws or manufacturer's standard to meet minimum diaphragm shear	24" max and as required to meet minimum diaphragm shear

B. Mechanical Fasteners:

1. Self-Drilling Screws:
 - a. Install screws in accordance with manufacturer's written instructions and with special installation tool. Do not over-torque.
 - b. Remove and redrive screws at sidelaps where upper sheet is not drawn tightly against lower sheet.
2. Powder Driven Fasteners:
 - a. Install fasteners in accordance with manufacturer's written instructions and with special installation tool.
 - b. Minimum Sidelap Edge Distance: 3/8 inch.
 - c. Minimum End/End Lap Distance: 1 inch.
 - d. Head Projection: As specified by manufacturer for correct penetration into flange of steel support member.

3.04 TOUCHUP PAINTING

- A. Immediately following erection, remove unused deck edge trimmings, screws, fasteners, welding washers, butt ends of welding rods, and debris from completed installation.
- B. Clean field welds, bolted connections, rust spots, and abraded areas.
- C. Repair damaged painted surfaces as specified in Section 09 90 00, Painting and Coating.
- D. Repair damaged galvanized surfaces with zinc-rich spray paint in accordance with ASTM A780; color to match galvanized deck.

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- E. Use magnetic gauge to determine that thickness of repair is equal to or greater than base painted or galvanized coating.

3.05 FIELD QUALITY CONTROL

- A. An independent testing agency will be retained by Owner to perform following inspections.
 - 1. Mechanical Fasteners: Visually inspect, in accordance with manufacturer's instructions, for each type of fastener.
- B. Repair or replace defective welds and fasteners.
- C. Special inspection will be provided by Owner where indicated on the Drawings.

END OF SECTION

SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

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

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

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

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

1.02 DEFINITIONS

- A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.
- B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.
- C. Exterior Area: Location not protected from weather by building or other enclosed structure.
- D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

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

1.03 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings: Metal fabrications, including welding and fastener information.
 - 2. Samples: Color samples of abrasive stair nosings.
- B. Informational Submittals: Passivation method for stainless steel members.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

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

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PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy 6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 304 (304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A56 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts

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Item	ASTM Reference
Anchor Bolts and Rods	F1554, Grade 36, with weldability supplement S1.
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grades C-1010 through C-1020
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

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

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on the Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

1. Plastic:
 - a. Single unit construction with corrugated sleeve.
 - b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
 - c. Material: High-density polyethylene.
2. Fabricated Steel: ASTM A36/A36M.

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2.03 POST-INSTALLED CONCRETE

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

2.04 STUD SHEAR CONNECTORS

- A. Headed anchor studs (HAS), or threaded anchor studs (TAS), or stud shear connectors, as indicated on the Drawings.
1. Carbon Steel: ASTM A108, Standard Quality Grades 1010 through 1020, inclusive either semikilled or killed aluminum or silicon dioxiation, unless indicated otherwise.
 2. Stainless Steel: ASTM F593, AISI Type 316, Condition CW, where indicated.
- B. Manufacturers:
1. Nelson Stud Welding, FabriSteel Co., Elyria, OH.
 2. Stud Welding Associates, Inc., Elyria, OH.

2.05 EMBEDDED STEEL SUPPORT FRAMES FOR FLOOR PLATE AND GRATING

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

2.06 ACCESSORIES

- A. Antiseizing Lubricant for Stainless Steel Threaded Connections:
1. Suitable for potable water supply.
 2. Resists washout.
 3. Manufacturers and Products:
 - a. Bostik, Middleton, MA; Neverseez.
 - b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.
- B. Neoprene Gasket:
1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on the Drawings.
 2. Thickness: Minimum 1/4 inch.
 3. Furnish without skin coat.

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4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

2.07 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures—Allowable Stress Design.

C. Welding:

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

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

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- E. Electrolytic Protection: Coat surfaces of aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
- F. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for use in contact with sewage. Cover full bearing surfaces.
- G. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.
- H. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.08 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

- A. General:
 - 1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
 - 2. Install rigid, substantial, and neat in appearance.
 - 3. Install manufactured products in accordance with manufacturer's recommendations.
 - 4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.
- B. Aluminum:
 - 1. Do not remove mill markings from concealed surfaces.
 - 2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
 - 3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

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C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.
3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

D. Steel Lintels and Shelf Angles: Provide as required for support of masonry and other construction not attached to structural steel framing, unless otherwise shown on the Drawings.

3.02 CAST-IN-PLACE ANCHOR BOLTS

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

3.03 ELECTROLYTIC PROTECTION

A. Aluminum:

1. Coat surfaces of aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Allow coating to dry before installation of the material.
3. Protect coated surfaces during installation.
4. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

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

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C. Stainless Steel:

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

3.04 PAINTING

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

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance:

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

B. Contractor-Furnished Quality Control:

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

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3.06 FASTENER SCHEDULE

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

Service Use and Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Stainless steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09 90 00, Painting and Coating
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09 90 00, Painting and Coating
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		
4.. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	

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Service Use and Location	Product	Remarks
5. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

- B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 DEFINITIONS

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

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

1.03 DESIGN REQUIREMENTS

- A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.
 - 1. Top Rail:
 - a. Capable of withstanding the following load cases applied:
 - 1) Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
 - 2) Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
 - 3) Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
 - 2. Calculated lateral deflection at top of posts shall not exceed 1.5-inch.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings:
 - a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
 - b. Manufacturer's literature and catalog data of railing and components.
 - c. Design Data:
 - 1) Calculations or test data using specified design performance loads and including the following:
 - a) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
 - b) Design of post base connection.
 - c) Documentation that concrete anchors have been designed in accordance with one of the following:
 - (1) ACI 318, Appendix D.
 - (2) ICC Evaluation Services Report for selected anchor.

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2. Samples:
 - a. Rail sections, 6 inches long showing each type of proposed connection, proposed finish, and workmanship.
 - b. Each fitting including wall brackets, castings, toeboard, and rail expansion joints.

B. Informational Submittals:

1. Manufacturer's assembly and installation instructions.
2. Special Inspection: Manufacturer's instructions for Special Inspection of post-installed anchors.
3. Test Reports:
 - a. Test data may supplement load calculations providing data covers complete railing system, including anchorage:
 - 1) Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
 - a) Railing and post connections.
 - b) Railing wall connections.
 - c) Railing expansion joint connections.
 - d) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.
 - 2) Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
 - 3) Deflection Criteria:
 - a) In accordance with ASTM E985 and design loads specified, except as follows:
 - (1) Maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
 - 4) Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
 - a. Test data may supplement load calculations providing data covers complete railing system, including anchorage:
 - 1) Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
 - a) Railing and post connections.
 - b) Railing wall connections.
 - c) Railing expansion joint connections.
 - d) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.
 - 2) Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
 - 3) Deflection Criteria:
 - a) In accordance with ASTM E985 and design loads specified, except as follows:
 - (1) Maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
 - 4) Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

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1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 ENVIRONMENTAL REQUIREMENTS

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

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

- A. General:
 - 1. Furnish pre-engineered and prefabricated railing systems as shown on the Drawings.
 - 2. Railing systems using pop rivets or glued railing construction are not permitted.
 - 3. Sand cast accessories and components are not permitted.
 - 4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

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B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, Alloy 6061-T6, "or-equal."
2. Tensile Strength: 38,000 pounds per square inch, minimum.
3. Yield Strength: 35,000 pounds per square inch, minimum.
4. Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

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

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- 3) Moultrie Manufacturing Co., Moultrie, GA; Part No. W60006.
- 8. Toeboards:
 - a. Molded or extruded Alloy 6063-T6 or Alloy 6061-T6 aluminum.
 - b. Provide slotted holes for expansion and contraction where required.
- 9. Fasteners: Stainless steel.
- D. Metal Supports Embedded in Concrete: In accordance with Section 05 50 00, Metal Fabrications.
- E. Finishes:
 - 1. Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
 - 2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

- A. Locknuts, Washers, and Screws:
 - 1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
 - 2. Flat Washers: Molded nylon.
- B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.
- C. Concrete Anchors:
 - 1. Stainless steel, AISI Type 316.
 - 2. Post-installed anchors in accordance with Section 05 50 00, Metal Fabrications, unless otherwise specified herein.
 - 3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

- A. Shop Assembly:
 - 1. Post Spacing: Maximum 6-foot horizontal spacing.
 - 2. Railing Posts Bolted to Metal or Concrete:
 - a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
 - b. Field fit-up is required.

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3. Free of burrs, nicks, and sharp edges when fabrication is complete.
 4. Welding is not permitted.
- B. Shop/Factory Finishing:
1. Use same alloy for uniform appearance throughout fabrication for railings.
 2. Railing and Post Fittings: Match fittings with color of pipe in railing.
- C. Shop Assembly:
1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
 2. Fit dowels tightly inside posts.
- D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

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

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3.02 RAILING INSTALLATION

- A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.
- B. Expansion Joints:
 - 1. Maximum intervals of 54 feet on center and at structural joints.
 - 2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
 - 3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
 - 4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.
- C. Posts and Rails:
 - 1. Surface Mounted Posts:
 - a. Bolt post baseplate connectors firmly in place.
 - b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
 - 2. Set posts plumb and aligned to within 1/8 inch in 12 feet.
 - 3. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
 - 4. Install posts and rails in same plane.
 - 5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
 - 6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
 - 7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.
- D. Wall Brackets: Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.
- E. Toeboard:
 - 1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
 - 2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
 - 3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
 - 4. Install plumb and aligned to within 1/8 inch in 12 feet.

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

3.03 FIELD FINISHING

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

3.04 FIELD QUALITY CONTROL

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

3.05 CLEANING

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

END OF SECTION

SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - d. B210/B210M, Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.
 - e. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 3. National Association of Architectural Metal Manufacturers (NAAMM): MBG 531, Metal Bar Grating Manual.

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
 - b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
 - c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
 - d. Manufacturer's specifications, including coatings, surface treatment, and finishes.
 2. Samples: Two Samples of grating approximately 4 inches by 8 inches, showing at least four crossbars each and four bearing bars each. One Sample will be retained at Site to be used as a basis for acceptance or rejection of grating installed.

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B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

1.03 DELIVERY, STORAGE, AND HANDLING

A. As far is practical, factory assemble items.

B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. IKG, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.

2.02 GRATING MATERIALS

A. Aluminum: Provide alloy and temper as designated below.

1. Bearing Bars and Banding: ASTM B221 Alloy 6061-T6 or Alloy 6063-T6.
2. Swaged Crossbar Rods: ASTM B221 Alloy 6061 or Alloy 6063, or ASTM B210/B210M Alloy 3003.
3. Finish: Mill.

2.03 LIGHT-DUTY AND MEDIUM-DUTY METAL BAR GRATING (TYPE A AND TYPE B)

A. General Requirements:

1. Maximum Service Load:
 - a. Light Duty (Type A): 100 psf uniformly distributed load.
 - b. Medium Duty (Type B): 500 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4-inch, whichever is less.
3. Bearing Bar Spacing:
 - a. Light Duty: 1-3/16-inch maximum, center-to-center.
 - b. Medium Duty: 15/16inch maximum, center-to-center.

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4. Cross Bar Spacing: 4 inches maximum, center-to-center. For aluminum I-bar grating with depths greater than 2 inches, provide cross bars at 2 inches maximum, center-to-center.
 5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on the Drawings.
- B. Grating Materials: Aluminum, pressure-locked I-bar grating fabricated by swaging crossbars between extruded I-shaped bearing bars.
- C. Surface: Striated.
- D. Stair Treads:
1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
 2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
 3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 ACCESSORIES

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

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4. Manufacturers and Products:
 - a. Welded Stud Anchor:
 - 1) Nelson Stud Welding, Inc., Elyria, OH.
 - 2) Stud Welding Associates, Inc. Elyria, OH.
 - b. Saddle Clip:
 - 1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
 - 2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
 - 3) Struct-Fast, Inc., Baltimore, MD; Grate-Fast.

2.05 FABRICATION

A. General:

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

- B. Light-Duty and Medium-Duty Metal Bar Grating: Single grating section shall be not less than 1.5 feet or greater than 3 feet in width or weigh more than 150 pounds.

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C. Supports:

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

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

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

3.02 INSTALLATION

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

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- J. Protect painted and galvanized surfaces during installation.
- K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

SECTION 07 41 13
METAL ROOF AND WALL PANELS

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - b. A792/A792M, Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
 - c. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - d. C1311, Standard Specification for Solvent Release Sealants.
 - e. D226, Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 - f. D523, Standard Test Method for Specular Gloss.
 - g. D1970, Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection.
 - h. D2178, Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing.
 - i. E283, Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
 - j. E331, Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.
 - k. E903, Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.
 - l. E1646, Standard Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference.
 - m. E1680, Standard Test Method for Rate of Air Leakage through Exterior Metal Roof Panel Systems.
2. FM (Factory Mutual) Global (FMG):
 - a. Approval Guide.
 - b. 4471, Approval Standard for Class 1 Panel Roofs.

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3. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Architectural Sheet Metal Manual.
4. UL: 580, Standard for Tests for Uplift Resistance of Roof Assemblies.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Drawings showing thickness and dimensions of parts and accessories, fastening and anchoring methods, details, and locations of seams, joints, and other provisions for thermal movement. Distinguish between factory-assembled and field-assembled work. Include drawings at not less than 1/4-inch to 1-foot scale and details at not less than 3-inch to 1-foot scale.
2. Samples:
 - a. Sheet Metal Roofing: 12-inch square Samples of specified metal for color verification. Custom color may be required.
 - b. Insulated Metal Roof and Wall Panels: 12-inch square Samples of specified metal for each type of panel for color verification. Custom color may be required.
 - c. Samples will be reviewed for color and texture only.

B. Informational Submittals:

1. Manufacturer's printed installation instructions.
2. A letter from roofing manufacturer stating roofer is approved by manufacturer to apply the roof.
3. Preinstallation Conference meeting minutes.
4. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator's Qualifications: Approved and trained by materials manufacturer.

B. Roofing Preinstallation Conference:

1. Before starting metal roof installation, conduct a conference with Engineer, roofing applicator, roofing system materials manufacturer, Subcontractors likely to be on roof, and installers whose work affects metal roof installation.
2. Items to be reviewed and discussed include, but are not limited to, the following items:
 - a. Examine roof deck or substrate conditions for compliance with requirements for flatness and tolerance of structural members.

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- b. Review structural loading limitations of roof deck or purlins and rafters during roofing installation.
- c. Review flashing details, roof drainage, roof insulation, roof penetrations, and other construction and conditions that might affect metal roof panel installation.
- d. Review governing regulations and requirements for insurance, certificates, and testing and inspecting as applicable.
- e. Review temporary protection requirements for metal roof panels during and after installation.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver components and metal roof and wall panels so as not to be damaged or deformed. Package for protection during transportation and handling.
- B. Storage and Handling:
 - 1. Protect against damage and discoloration.
 - 2. Handle panels with nonmarring slings.
 - 3. Do not bend panels.
 - 4. Store panels aboveground on pallets or platforms, with one end elevated for drainage.
 - 5. Protect strippable protective covering from exposure to sunlight except as necessary for metal roof and wall installation.
 - 6. Stack panels to prevent twisting, bending, or abrasion, and to provide ventilation.
 - 7. Protect panels against standing water and condensation between adjacent surfaces.
 - 8. If panels become wet, immediately separate sheets, wipe dry with clean cloth, and separate sheets for air-drying.
 - 9. During storage prevent contact with materials that may cause discoloration or staining.

1.05 COORDINATION

- A. Coordinate work with construction of decks, walls, and other adjoining work.

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1.06 SPECIAL GUARANTEE

- A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction or, at the option of the Owner, removal and replacement of roofing panels, flashing, finish, and accessories found defective during a period of 20 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified the General Conditions.
- B. Conditions:
 - 1. Roofing Panels: No rupture, structural failure, or perforation.
 - 2. Finish (for all panels): No cracking, blistering, flaking, chipping, checking, chalking, peeling, or fading.
 - 3. Components: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 CANOPY ROOF PANELS

- A. Material: Prefinished Galvalume/Zincalume, ASTM A792 Aluminum-Zinc Alloy coating designation Grade 40, ASTM A792/A792M coated steel, 24-gauge.
- B. Surface: Smooth, flat finish.
- C. Finish:
 - 1. Polyvinylidene Fluoride: Kynar 500, two coats minimum.
- D. Color: Color as scheduled on the Drawings.
- E. Standing Seam, Seamed Joint:
 - 1. Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically space between vertical ribs designed for independent field installation by mechanically attaching panels to supports using concealed clips located under one side of panel and engaging opposite edge of adjacent panels and mechanically seaming panels together.
 - 2. Panel Coverage: Minimum 16 inches, maximum 18 inches.
 - 3. Panel Height: 2 inches.
 - 4. Sealant: Factory applied.

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5. Manufacturers and Products: Basis of Design.
 - a. Centria; SDP200.
 - b. Kingspan; SLR Series.
 - c. AEP Span, SpanSeam.
 - d. "Or-equal."

2.02 WALL PANELS

A. Metal Wall Panels:

1. Materials and Configuration:
 - a. Factory-assembled insulated preformed metal panels with manufacturer's standard concealed fasteners, and gasketed seam system of double tongue and groove interlocking joint.
 - b. Core: Insulating polyisocyanurate foam bonded to face sheets.
 - c. 22-gauge, sheet metal panels meeting ASTM A792/A792M, Grade 50, minimum.
 - d. Finish: Factory-applied, 70 percent fluoropolymer coating, dry film thickness of 1.0 mil including primer, in custom color as scheduled.
2. Box Rib Panel:
 - a. Panel Coverage: Minimum 16 inches.
 - b. Box Depth: 2 inches.
 - c. Sealant: Factory applied.
 - d. Manufacturers and Products: Basis of Design.
 - 1) Taylor Metals.
 - 2) AEP Span.
 - 3) "Or-equal."

2.03 ACCESSORIES

A. Self-Adhering Underlayment:

1. Ice and water shield, cold applied, self-adhering, polyethylene-faced sheet, consisting of slip-resisting polyethylene-film reinforcing top surface laminated to SBS-modified asphalt adhesive with release-paper backing, 40-mil minimum thickness meeting ASTM D1970.
2. Manufacturers and Products:
 - a. Grace Construction Products; Grace Ice & Water Shield.
 - b. Carlisle Coatings and Waterproofing; CCW WIP 300HT Water and Ice Protection.

- B. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads.

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Provide exposed fasteners with heads matching color of metal by means of plastic caps or factory-applied coating.

1. Fasteners: Self-drilling or self-tapping Type 410 stainless steel or zinc-alloy steel hex washer head with EPDM or PVC washer.
 2. Fasteners for Flashing and Trim: Self-drilling screws with hex washer head or blind fastener rivets of high-strength aluminum or stainless steel.
- C. Holddown Clips: System manufacturer's ASTM A792/A792M standard shape steel.
- D. Closures: Manufacturer's standard neoprene blocks shaped to fit roof metal profile.
- E. Sealant:
1. Joint Sealant: Type 5 as specified in Section 07 92 00, Joint Sealants.
 2. Butyl Sealant: Butyl-rubber based, solvent-release sealant per ASTM C1311.
- F. Isolation Paint: As specified in Section 09 90 00, Painting and Coating.

2.04 FABRICATION

- A. Fabricate and finish metal roof, wall and canopy roof panels, and accessories at factory to the greatest extent possible.
- B. Provide panel profile, including major ribs and any intermediate stiffening ribs for full panel length.
- C. Panel Length: Roof and canopy roof panels shall be full length from eave to ridge, unless otherwise indicated or limited by shipping limitations. Where indicated, fabricate metal roof and canopy roof panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact.
- E. Form and fabricate sheets, cleats, edge treatments, integral flashings, and other components of specified metal roofing panels to profiles, patterns, and drainage arrangement shown, and as required for permanent leakproof construction, and as recommended by SMACNA's "Architectural Sheet Metal Manual."
- F. Provide for thermal expansion and contraction of Work.

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- G. Conceal fasteners and methods of expansion where possible. Do not use exposed fasteners on faces of accessories where exposed to view.
- H. Finishes:
 - 1. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half the range of approved sample. Noticeable variations within same piece are not acceptable. Variations in other component appearances are acceptable if within range of approved samples and are assembled or installed to minimize contrast.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions for compliance with alignment tolerances required by metal roof panel manufacturer.
- B. Prior to beginning installation, examine rough-in location for items penetrating metal roof panels and coordinate with seam locations.

3.02 PREPARATION

- A. Deck: Firm, dry, free of foreign materials, and smooth. Report immediately to Engineer cracks, breaks, holes, or other unusual irregularities in surface.
- B. Layout Pattern:
 - 1. Lay out to place seams equidistant from corners and aligned with seams on other side of hip or ridge.
 - 2. Coordinate Work of this section with flashing, trim, and other construction to provide a permanently leakproof, secure, and noncorroding installation.

3.03 INSTALLATION

- A. General:
 - 1. Apply roofing only in dry weather and where weather conditions permit.
 - 2. Install in accordance with manufacturer's written instructions and warranty requirements.
 - 3. Comply with recommendations of the SMACNA "Architectural Sheet Metal Manual."

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4. Install metal roofing system consisting of nonstructural sheet metal panels held to substrate with concealed fasteners.
5. Conceal expansion joint provisions wherever possible in exposed Work; locate so as to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
6. Closures and Trim:
 - a. Provide eaves, rakes, and other exposed trim and flashing for a weather-tight roofing system.
 - b. Provide metal closures at peaks and rake edges.
 - c. Flash and seal metal roof panels with weather closures at eaves, rakes, and at perimeter of openings. Fasten with self-tapping screws.
7. Dissimilar Metals:
 - a. Separate from each other where electrolysis might occur.
 - b. Separate metal panels where contact with corrosive substrates may occur.
 - c. Separation is satisfactorily accomplished by coating metals with isolation paint.
 - d. Comply with various metals producers' recommendations for other forms of protection against contamination from corrosive materials or agents.
8. Lap metal flashing over metal roof panels to allow moisture to run over and off the material.
9. Cutting and Fitting: Neat, square, and true. Saw cut panels, deburr, and use touchup paint immediately as recommended by roofing panel manufacturer. Torch cutting is prohibited.

B. Insulated Metal Roof, Insulated Metal Wall, and Canopy Roof Panels:

1. Install as recommended by metal panel manufacturer's installation instructions and recommendations.
2. Begin at eaves. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction.
3. Install clips in panel side joints at location, spacing, and with fasteners as recommended by manufacturer for type of substrate and wind loading specified.

3.04 CLEANING AND PROTECTION

A. Cleaning:

1. At the end of each day sweep metal clean of foreign materials, especially metal particles and scrap.
2. Peel off strippable film.

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3. Where needed, clean metals in conformance with metals industry recommendations or use Basic H organic metal cleaner, Shaklee Products, Hayward, CA.

B. Protection:

1. Protect material from exposure to chlorides, hydrochloric-based and muriatic acids. If contaminated, wash affected areas immediately with 5 percent soda and water solution and rinse with clear water.
2. Avoid walking on roof after completion.

C. Final Cleanup:

1. Remove debris, metal clips, nails, and other materials that could prevent adequate drainage or produce corrosion products through electrolysis.
2. Repair and touch up damage.
3. Replace metal roof panels that have been damaged or have deteriorated beyond successful repair.

END OF SECTION

SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. C661, Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer.
 - b. C834, Standard Specification for Latex Sealants.
 - c. C920, Standard Specification for Elastomeric Joint Sealants.
 - d. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Informational Submittals:

1. Installation instructions.
2. Documentation showing applicator qualifications.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum of 5 years' experience installing sealants in projects of similar scope.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

1.05 SPECIAL GUARANTEE

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

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correction or removal and replacement of defective Work is specified in the General Conditions.

- B. Conditions: No adhesive or cohesive failure of sealant.
- C. Sealed Joints: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

- A. Characteristics:
 - 1. Uniform, homogeneous.
 - 2. Free from lumps, skins, and coarse particles when mixed.
 - 3. Nonstaining, nonbleeding.
 - 4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
 - 5. Immersible may be substituted for nonimmersible provided all other specified requirements are met.
- B. Color: Unless specifically noted, match color of the principal material adjoining area of application.
- C. Type 5—One-part Polyurethane, Immersible:
 - 1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or Grade P, Class 25.
 - 2. Capable of being continuously immersed in water.
 - 3. Manufacturers and Products for Nonsag:
 - a. Sika Corp.; Sikaflex-1a.
 - b. Tremco; Vulkem 116.
 - 4. Manufacturers and Products for Self-leveling:
 - a. Master Builders Solutions Construction Systems US; MasterSeal SL-1.
 - b. Tremco; Vulkem 45SSL.
 - c. Sika Corp.; Sikaflex-1c SL.

2.02 BACKUP MATERIAL

- A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

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- B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16-inch wide.
- C. Manufacturers and Products:
 - 1. Tremco; Closed-cell Backing Rod.
 - 2. W.R. Meadows; Cera-Rod and Kool-Rod.

2.03 ANCILLARY MATERIALS

- A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.
- B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.
- C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

2.04 PREFORMED SEALS

- A. Preformed Compressible Joint Seals:
 - 1. Widths Up to 5 Inches:
 - a. BASF, Watson Bowman Acme Div.; Wabo Weatherseal II.
 - b. Sika Corp., Emseal Joint Systems, Ltd.; Seismic Colorseal.
 - c. LymTal International; Iso-flex Compression Seal Expansion Joint System.
 - 2. Other Widths: Series or model recommended by seal manufacturer.

PART 3 EXECUTION

3.01 GENERAL

- A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.
- B. Install joint sealants in accordance with ASTM C1193.
- C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.
- D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

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- E. Use joint sealant as required for the applicable application and as follows:

<u>Joint Size</u>	<u>Sealant Type</u>
Less than 1"	5

3.02 PREPARATION

- A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.
- B. Sealed surfaces to be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.
1. Mask adjacent surfaces where necessary to maintain neat edge.
 2. Starting of work will be construed as acceptance of subsurfaces.
 3. Apply primer to dry surfaces as recommended by sealant manufacturer.
- C. Verify joint shaping materials and release tapes are compatible with sealant.
- D. Examine joint dimensions and size materials to achieve required width or depth ratios.
- E. Follow manufacturer's instructions for mixing multi-component products.

3.03 INSTALLATION

- A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.
1. Install backup material as recommended by sealant manufacturer.
 2. Where possible, provide full length sections without splices; minimize number of splices.
 3. Tape sealant may be used as joint filler if approved by sealant manufacturer.
- B. Use bond breaker where recommended by sealant manufacturer.
- C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.
- D. Joint Sealant Materials: Follow manufacturer's recommendation and instructions, filling joint completely from back to top, without voids.

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- E. Joints: Tool slightly concave after sealant is installed.
 - 1. When tooling white or light color sealant, use a water wet tool.
 - 2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.
- F. Tape Sealant: Compress to 50 percent of expanded thickness and install in accordance with manufacturer's instructions.

3.04 PREFORMED SEALS

- A. Prepare joint surfaces clean and dry, free from oil, rust, laitance, and other foreign material.
- B. Construct joints straight and parallel to each other and at proper width and depth.
- C. Apply joint sealant manufacturer's approved primer and adhesive in accordance with manufacturer's instructions.
- D. Install seal in accordance with manufacturer's instructions.

3.05 CLEANING

- A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.
- B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

3.06 JOINT SEALANT SCHEDULE

- A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Masonry Walls	5

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

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

1.02 DEFINITIONS

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

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

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Data Sheets:
 - 1) For each product, furnish a Paint Product Data Sheet (PPDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PPDS form is appended to the end of this section.
 - 2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
 - 3) Technical and performance information that demonstrates compliance with specification.
 - 4) Furnish copies of paint system submittals to the coating applicator.
 - 5) Indiscriminate submittal of only manufacturer's literature is not acceptable.
 - b. Detailed chemical and gradation analysis for each proposed abrasive material.
2. Samples:
 - a. Proposed Abrasive Materials: Minimum 5-pound sample for each type.
 - b. Reference Panel:
 - 1) Surface Preparation:
 - a) Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
 - b) Provide panel representative of the steel used; prevent deterioration of surface quality.
 - c) Panel to be reference source for inspection upon approval by Engineer.

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2) Paint:

- a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.
- b) Furnish additional samples as required until colors, finishes, and textures are approved.
- c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

- 1. Applicator's Qualification: List of references substantiating experience.
- 2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
- 3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
- 4. Manufacturer's written verification that submitted material is suitable for the intended use.
- 5. Coating for Faying Surfaces: Manufacturer's test results that show the proposed coating meets the slip resistance requirements of the AISC Specification for Structural Joints using ASTM A325 or ASTM A490 bolts.
- 6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
- 7. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

B. Regulatory Requirements:

- 1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
- 2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC PA 10.
 - c. Federal, state, and local agencies having jurisdiction.

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C. Mockup:

1. Before proceeding with Work under this section, finish one complete item or 4 feet by 4 feet space of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

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- B. Minimum of 5 years' verifiable experience in manufacture of specified product.
- C. Each of the following manufacturers is capable of supplying most of the products specified herein:
 - 1. Azko Nobel (Devoe: International).
 - 2. Carboline.
 - 3. PPG.
 - 4. Sherwin-Williams.
 - 5. Tnemec.

2.02 PAINT MATERIALS

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

Product	Definition
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Epoxy Primer— Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service

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Product	Definition
Organic Zinc Rich Primer	Epoxy or moisture cured urethane with 85-percent zinc content in the dry film, meeting the requirements of RCSC Specification for Structural Joints using High Strength Bolts, Class A or Class B, as required.
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
PVC Tape Wrap	20-mil thick PVC tape wrap with high tack adhesive, suitable for buried applications. Width as recommended by manufacturer for the pipe diameter to be coated.
Moisture Cured Urethane	High-solids, single component, aliphatic, moisture-cure urethane.
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required

2.03 MIXING

A. Multiple-Component Coatings:

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

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

2.04 SHOP FINISHES

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

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

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C. Shop Coating Requirements:

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

D. Pipe:

1. Ductile Iron Pipe:
 - a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
 - b. The surface preparation and application of the primer shall be performed by pipe manufacturer.
 - c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
 - d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
2. Steel Pipe:
 - a. Surface preparation and application of primer shall be performed by pipe manufacturer.
 - b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

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

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3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

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

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

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B. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
 - a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
 - b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
 - c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
 - d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
 - e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
 - f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.
 - g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
 - h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

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- i. SP 16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).
2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
 - a. Prepare such that there is:
 - 1) No undercutting or reverse ridges on weld bead.
 - 2) No weld spatter on or adjacent to weld or any area to be painted.
 - 3) No sharp peaks or ridges along weld bead.
 - b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
 - a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
 - b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
 - c. Clean small, isolated areas as above or solvent clean with suitable solvent and clean cloth.
9. Blast Cleaning Requirements:
 - a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer’s recommendations.

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- b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
 - c. Use only dry blast cleaning methods.
 - d. Do not reuse abrasive, except for designed recyclable systems.
 - e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
- 10. Post-Blast Cleaning and Other Cleaning Requirements:
 - a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
 - b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.
- C. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:
 - 1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
 - 2. Brush blast in accordance with SSPC SP 16.
 - 3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.
- D. Concrete Surface Preparation:
 - 1. Do not begin until 30 days after concrete has been placed.
 - 2. Meet requirements of SSPC SP 13.
 - 3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
 - 4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
 - 5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
 - 6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

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E. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

F. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.
7. Application of Cosmetic Coat:
 - a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
 - b. Check compatibility by application to a small area prior to starting painting.
 - c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

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B. Acid Etching:

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

C. Solvent Cleaning:

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

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for existing and new, interior and exterior masonry, concrete, and metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.

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

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

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

C. Porous Surfaces, Such as Concrete and Masonry:

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

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D. Film Thickness and Coverage:

1. Number of Coats:
 - a. Minimum required without regard to coating thickness.
 - b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
 - a. Do not exceed coating manufacturer's recommendations.
 - b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
 - a. Perform with properly calibrated instruments.
 - b. Recoat and repair as necessary for compliance with specification.
 - c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

- A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.
- B. Additional requirements are included in the Piping Schedule on the Drawings.

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C. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	Coal-Tar Epoxy -OR-	2 coats, 16 MDFT
	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
 - a. Metal surfaces below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, metal surfaces that are below the top of a containment structural wall holding water (such as UV Channels 1 and 2) concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel, and the following specific surfaces:
 - 1) As shown on the Pipe Schedule.

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

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

1. Use on the following items or areas:
 - a. Exposed metal surfaces, new and located inside or outside of structures and exposed to weather, and the following specific surfaces:
 - 1) Above a water holding structure, such as the UV Channels 1 and 2, and as indicated in the Pipe Schedule.
 - 2) For insulated pipe, omit the polyurethane finish coat. Verify epoxy coating products a suitable for 200 degrees F.

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E. System No. 5 Exposed Metal—Mildly Corrosive:

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

1. Use on the following items or areas:
 - a. Exposed metal surfaces, new and located inside or outside of structures and exposed to weather or in a highly humid atmosphere.

F. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Coal-Tar Epoxy OR	2 coats, 16 MDFT
	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
 - a. Use on concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles; and as shown on the Pipe Schedule.

G. System No. 8 Buried Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	High Build Epoxy -OR- Coal-Tar Epoxy	2 coats, 16 MDFT

1. Use on buried ferrous metal, belowgrade portions of steel items, except where otherwise specified and the following specific surfaces:
 - a. Dissimilar metal connections.
2. Alternatively, Contractor may supply pipe fittings and appurtenances with shop applied fusion bonded epoxy as specified herein.

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

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

1. Use on the following items or areas:
 - a. Galvanized surfaces requiring painting.
 - b. After application of System No. 10, apply finish coats as required for exposure.
 - c. For buried copper, see System No. 30.

- I. System No. 11 Faying Surfaces of Slip Critical Bolted Connections:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Organic Zinc Rich Primer	1 coat 3 MDFT

1. Use on faying surfaces of slip critical joints as specified and as shown on the Drawings.
2. Provide primer in accordance with RCSC Specification for Structural Joints using High-Strength Bolts.

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J. System No. 19a Concrete Exposed Metal Repair Coating—Wastewater:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1.	Amine-cured epoxy, suitable for exposure to primary wastewater, finish color gray.	2 coats, 8 MDFTPC, see Note 2.
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. On saw-cut concrete surfaces that intersects, and exposes ends of reinforcing steel and metal embeds where the concrete surface will not be coated by another specified coating system. Coat the entire area of the saw cut. Or alternately, where approved, over ends of and minimum two inches around ends of exposed metal and rebar in lieu of entire surface.

K. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex Semigloss	2 coats, 320 SFPGPC

1. Use on the following items or areas:
 - a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.

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L. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete.

M. System No. 29 Fusion Bonded Epoxy:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating	1 or 2 coats, 7 MDFT

1. For steel pipe and fittings, meet all requirements of AWWA C213.

N. System No. 30 Buried Copper:

1. Tape Coat:
 - a. Minimum 20-mil tape, 50 percent overlap, 2-inch width, 100 percent elongation.
 - b. Holiday free.
 - c. Manufacturer: 3M.

O. System No. 31 Wax Tape:

1. This coating system shall be used for buried nuts, bolts, flanges, flexible couplings, thrust ties and other joints with irregular surfaces.
2. Wax tape coat system herein is specified around Tapecoat products. Contractor may submit equal product for approval.
 - a. Prepare surface per manufacturers manufacturer guide.
 - b. Prime with Tapecoat Color Coat Primer, minimum 4 wet mils.
 - c. Tapecoat putty all gaps and irregular surfaces which the wax tape wrap is unable to contour.
 - d. Apply Tapecoat Envirotape around all appurtenances with min 20 percent overlap.
 - e. Wax tape may require pressure to help conform to surface.
 - f. Wax tape should be free of voids and large wrinkles. The tape can be cut with scissors to make the application easier for complicated structures.

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3.08 COLORS

- A. Provide as shown for equipment and appurtenances and designated herein and shown in Piping Schedule on the Drawings.
- B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.
- C. Equipment Colors:
 - 1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
 - 2. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
 - a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
 - b. Fire Protection Equipment and Apparatus: OSHA Red.
 - c. Radiation Hazards: OSHA Purple.
 - d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

3.09 FIELD QUALITY CONTROL

- A. Testing Equipment:
 - 1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.
 - 2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
 - 3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.
- B. Testing:
 - 1. Thickness and Continuity Testing:
 - a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.

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- b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
 - c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
 - d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.
- C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.
- D. Unsatisfactory Application:
 - 1. If item has an improper finish color or insufficient film thickness, clean surface, and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
 - 2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
 - 3. Repair defects in accordance with written recommendations of coating manufacturer.
- E. Damaged Coatings, Pinholes, and Holidays:
 - 1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
 - 2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
 - 3. Feather edges and repair in accordance with recommendations of paint manufacturer.
 - 4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

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3.10 MANUFACTURER'S SERVICES

- A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:
 - 1. On first day of application of any coating system.
 - 2. A minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
 - 3. As required to resolve field problems attributable to or associated with manufacturer's product.
 - 4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.11 CLEANUP

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

3.12 SUPPLEMENTS

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

END OF SECTION

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PAINT SYSTEM DATA SHEET (PSDS)

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

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

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PAINT PRODUCT DATA SHEET (PPDS)

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

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

Provide manufacturer's recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning: _____

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

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

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

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

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

1.02 REFERENCES

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

1.03 DESIGN REQUIREMENTS

- A. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.

1.04 SUBMITTALS

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

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1.05 QUALITY ASSURANCE

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

1.06 ENVIRONMENTAL CONDITIONS

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

PART 2 PRODUCTS

2.01 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

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- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

2.02 EQUIPMENT FINISH

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

2.03 NAMEPLATES

- A. Material: Laminated plastic.
- B. Attachment Screws:
 - 1. Stainless steel.
 - 2. Adhesive: Single-part, room temperature vulcanizing adhesive suitable for the environment and materials installed. Use adhesive on NEMA 4 or NEMA 4X enclosures only.
- C. Color: White, engraved to a black core.
- D. Letter Height:
 - 1. Pushbuttons/Selector Switches: 1/8 inch.
 - 2. Other Electrical Equipment: 1/4 inch.

2.04 SIGNS AND LABELS

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

PART 3 EXECUTION

3.01 GENERAL

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

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

3.02 ANCHORING, BRACING, AND MOUNTING

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

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. The Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

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

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B. Available Fault Current Signs:

1. Install label on service equipment to indicate the maximum available fault current at the equipment. Labels shall be of sufficient durability for the environment in which the equipment is installed. Labels shall include the following information:
 - a. Equipment name or identification.
 - b. Available fault current at the equipment.
 - c. Date the fault current calculations were performed.
2. Use bolted fault current and equipment name from study required in Section 26 05 70, Electrical Systems Analysis, as basis for the label.
3. Where existing electrical systems are modified, completely remove existing fault current labels if present, and install new labels in accordance with the above requirements.

C. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.

D. Equipment Nameplates:

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

3.05 LOAD BALANCE

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

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3.06 CLEANING AND TOUCHUP PAINTING

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

3.07 PROTECTION FOLLOWING INSTALLATION

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

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

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

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

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

1.02 SUBMITTALS

A. Action Submittals:

- 1. Provide manufacturers' data for the following:
 - a. Circuit breakers.
 - b. Nonfused switches.
 - c. Firestopping.
 - d. Enclosures: Include enclosure data for products having enclosures.
- 2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

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

B. Operating Mechanism:

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

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- C. Trip Mechanism:
1. Individual permanent thermal and magnetic trip elements in each pole.
 2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 3. Two and three pole, common trip.
 4. Automatically opens all poles when overcurrent occurs on one pole.
 5. Test button on cover.
 6. Calibrated for 40 degrees C ambient, unless shown otherwise.
 7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
- D. Short Circuit Interrupting Ratings: Greater than, or equal to, available fault current or interrupting rating shown.
- E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
1. Ground fault sensor shall be rated same as circuit breaker.
 2. Push-to-test button.
- F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).
- G. Magnetic Only Type Breakers: Where shown, instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.
- H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
- I. Connections:
1. Supply (line side) at either end.
 2. Mechanical wire lugs, except crimp compression lugs where shown.
 3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
 4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

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5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

J. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

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

2.03 SUPPORT AND FRAMING CHANNELS

- A. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

2.04 FIRESTOPS

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

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B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 Series and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

2.05 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections:
1. Dry Area: NEMA 250 Type 1.
 2. Wet and Corrosive Area: NEMA 250 Type 4X, 304 Stainless Steel.

PART 3 EXECUTION

3.01 GENERAL

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

3.02 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.
- B. Channel Type: Indoor corrosive and wet areas.
- C. Paint cut ends prior to installation with the following:
1. Carbon Steel Channel: Zinc-rich primer.

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3.03 FIRESTOPS

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

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

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

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- d. WC 71, Standard for Nonshielded Cables Rated 2,001-5,000 Volts for Use in the Distribution of Electric Energy.
 - e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
- 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- 7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
- 8. UL:
 - a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.
 - h. 1072, Standard for Safety for Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Standard for Safety for Metal-Clad Cables.
 - k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

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

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

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

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

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

2.02 600-VOLT RATED CABLE

- A. General:
 1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 3. Suitable for installation in open air, in cable trays, or conduit.
 4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
 5. Overall Outer Jacket: PVC, flame-retardant, sunlight-resistant and oil-resistant.

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B. Type 1, Multiconductor Control Cable:

1. Conductors:
 - a. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Manufacturers:
 - a. Okonite Co.
 - b. Southwire.

C. Type 2, Multiconductor Power Cable:

1. General:
 - a. Meet or exceed UL 1581 for cable tray use.
 - b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
 - c. Overall Jacket: PVC.
2. Conductors:
 - a. Class B stranded, coated copper.
 - b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
 - c. UL rated VW-1 or listed Type XHHW-2.
 - d. Color Code:
 - 1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
 - 2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.
3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Manufacturers:
 - a. Okonite Co.
 - b. Southwire.

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

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.

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3. Dimension: 0.31-inch nominal OD.
4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

2.03 SPECIAL CABLES

- A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
 1. Category 6 UTP, IL Listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 4. NFPA Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
 5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
 6. Manufacturer and Product:
 - a. Belden; 7852A.
 - b. "Or-equal."
- B. Type 31, MODBUS Cable:
 1. Manufacturer and Product:
 - a. Belden; 3106A.
 - b. "Or-equal."

2.04 GROUNDING CONDUCTORS

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

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2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M, Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth, 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

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

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C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy; Hydent.
 - 3) ILSCO.

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- 4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
- E. Cable Ties:
 - 1. Nylon, adjustable, self-locking, and reusable.
 - 2. Manufacturer and Product: Thomas & Betts, TY-RAP.
- F. Heat Shrinkable Insulation:
 - 1. Thermally stabilized cross-linked polyolefin.
 - 2. Single wall for insulation and strain relief.
 - 3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
 - 4. Manufacturers and Products:
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.
- G. Data Cable Accessories: Terminators, connectors, and junctions for a complete Ethernet system.

2.06 PULLING COMPOUND

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

2.07 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 GENERAL

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

3.02 POWER CONDUCTOR COLOR CODING

- A. Conductors 600 Volts and Below:
 - 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
 - 2. 8 AWG and Smaller: Provide colored conductors.

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3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

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

3.03 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.
- C. Circuits Not Appearing in Circuit Schedules:
 - 1. Assign circuit name based on device or equipment at load end of circuit.
 - 2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

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D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

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

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E. Splices and Terminations:

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

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

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

H. Control and Instrumentation Wiring:

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

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

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Product data for the following:
 - 1) Ground rods.
 - 2) Mechanical connectors.
 - 3) Compression connectors.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

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PART 2 PRODUCTS

2.01 GROUND ROD

- A. Material: Copper-clad.
- B. Diameter: Minimum 5/8 inch.
- C. Length: 10 feet.

2.02 GROUND CONDUCTORS

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

2.03 CONNECTORS

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

PART 3 EXECUTION

3.01 GENERAL

- A. Grounding: In compliance with NFPA 70 and IEEE C2.
- B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

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

3.02 WIRE CONNECTIONS

- A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.
- B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Connect ground conductors to raceway grounding bushings.
- D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.
- E. Connect enclosure of equipment containing ground bus to that bus.
- F. Bolt connections to equipment ground bus.
- G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.
- H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

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- I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

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

3.04 GROUND RODS

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

3.05 CONNECTIONS

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

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B. Compression Type:

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

C. Mechanical Type:

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

3.06 METAL STRUCTURE GROUNDING

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

3.07 MANHOLE AND HANDHOLE GROUNDING

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

3.08 TRANSFORMER GROUNDING

- A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.

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3.09 SURGE PROTECTION EQUIPMENT GROUNDING

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

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 3. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
 4. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - c. C80.3, Steel Electrical Metallic Tubing (EMT).
 - d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
 - e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
 - f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - k. VE 1, Metallic Cable Tray Systems.

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5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
7. UL:
 - a. 1, Standard for Safety for Flexible Metal Conduit.
 - b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
 - c. 6, Standard for Safety for Electrical Rigid Metal Conduit-Steel.
 - d. 6A, Standard for Safety for Electrical Rigid Metal Conduit-Aluminum, Red Brass and Stainless.
 - e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
 - g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
 - j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
 - k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
 - l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
 - m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
 - a. Conduit.
 - b. Junction and pull boxes used at or below grade.
 - c. Large junction and pull boxes.
 - d. Terminal junction boxes.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's certification of training for PVC coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

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

B. PVC Schedule 40 Conduit:

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

C. PVC-Coated Rigid Galvanized Steel Conduit:

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

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D. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

E. Flexible, Nonmetallic, Liquid-Tight Conduit:

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

2.02 FITTINGS

A. Rigid Galvanized Steel:

1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturers and Products:
 - 1) Appleton; Series BU-I.
 - 2) O-Z/Gednet; Type HB.
3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
 - b. Manufacturers and Products:
 - 1) Appleton; Series GIB.
 - 2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) Appleton, Series HUB-B.
 - 2) O-Z/Gedney; Series CH.
 - 3) Meyers; ST Series.

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5. Conduit Bodies:
 - a. Sized as required by NFPA 70.
 - b. Manufacturers and Products (For Normal Conditions):
 - 1) Appleton; Form 35 threaded unilets.
 - 2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
 - 3) Killark; Series O electrolets.
 - 4) Thomas & Betts; Form 7 or Form 8.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
 - a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - 1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
 - 2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYF, EYM, or ESU.
 - 2) Crouse-Hinds; Type EYS or EZS.
 - 3) Killark; Type EY or Type EYS.
9. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYD.
 - 2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.
11. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement:
 - a) Appleton; Type DF.
 - b) Crouse-Hinds; Type XD.
 - 2) Expansion Movement Only:
 - a) Appleton; Type XJ.
 - b) Crouse-Hinds; Type XJ.
 - c) Thomas & Betts; XJG-TP.
12. Cable Sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2-inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:
 - 1) Appleton; CG-S.
 - 2) Crouse-Hinds; CGBS.

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B. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

C. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
8. Expansion Fitting:
 - a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

D. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.

E. Flexible, Nonmetallic, Liquid-Tight Conduit:

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

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F. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and Division 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
 - a. Crouse-Hinds; Type ECGJH or Type ECLK.
 - b. Appleton; EXGJH or EXLK.

2.03 OUTLET AND DEVICE BOXES

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

B. Cast Metal:

1. Box: Malleable iron or Cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron or cast ferrous metal with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or Type FD.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
6. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA or Type EAJ.
 - b. Appleton; Type GR.

C. Nonmetallic:

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

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

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C. Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion resistant.

D. Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron or ferrous metal, electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with clamps.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
 - a. Crouse-Hinds; Series W.
 - b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type:
O-Z/Gedney; Series YW.
8. Manufacturer and Products, Recessed Type:
 - a. Crouse-Hinds; Type WJBF.
 - b. O-Z/Gedney; Series YR.

E. Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 304 or Type 316 stainless steel with white enamel painted interior mounting panel.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.

F. Steel Box:

1. NEMA 250 Type 1.
2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphate surfaces. Provide gray finish as approved by Engineer.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.

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5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.

G. Nonmetallic Box:

1. NEMA 250 Type 4X.
2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Conduit hubs and mounting lugs.
6. Manufacturers and Products:
 - a. Crouse-Hinds; Type NJB.
 - b. Carlon; Series N, C, or H.
 - c. Robroy Industries.

H. Concrete Box, Traffic Areas:

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

2.05 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
 - a. Nonmetallic, interlocking, for multiple conduit sizes.
 - b. Suitable for all types of conduit.
 - c. Manufacturers:
 - 1) Underground Device, Inc.
 - 2) Carlon.
2. Template Type:
 - a. Nonmetallic, custom made one-piece spacers.
 - b. Suitable for all types of conduit.
 - c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
 - d. Conduit openings cut 1-inch larger than conduit outside diameter.
 - e. Additional openings for stake-down, rebar, and concrete flow through as required.
 - f. Manufacturer and Product: SP Products, Quik Duct.

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B. Identification Devices:

1. Raceway Tags:
 - a. Material: Permanent, nonferrous metal.
 - b. Shape: Round.
 - c. Raceway Designation: Pressure stamped, embossed, or engraved.
 - d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
 - a. Material: Polyethylene, 4-mil gauge with detectable strip.
 - b. Color: Red.
 - c. Designation: Warning on tape that electric circuit is located below tape.
 - d. Identifying Letters: Minimum 1-inch-high permanent black.

C. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

D. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
 - a. Raychem.
 - b. 3M.

E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

- A. Comply with NECA Installation Standards.
- B. Crushed or deformed raceways not permitted.
- C. Maintain raceway entirely free of obstructions and moisture.
- D. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

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

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3.02 REUSE OF EXISTING CONDUITS

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

3.03 CONDUIT APPLICATION

- A. Diameter: Minimum 3/4-inch.
- B. Exposed: PVC coated rigid galvanized steel.
- C. Interior, Exposed: Rigid galvanized steel.
- D. Direct Earth Burial: PVC Schedule 40.
- E. Concrete Encased Ductbank: PVC Schedule 40.
- F. Under Slabs On Grade: PVC Schedule 40.
- G. Transition from Underground or Concrete Embedded to Exposed: PVC coated rigid steel.
- H. Under Equipment Mounting Pads: PVC Schedule 40.
- I. Corrosive Areas: PVC coated rigid galvanized steel.

3.04 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:
 - 1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
 - 2. Conduit Size Over 4 Inches: Nonflexible.

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- 3. Wet or Corrosive Areas: Flexible, nonmetallic liquid-tight.
- 4. Dry Areas: Flexible, metallic liquid-tight.
- B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.
- D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.05 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.
- D. Apply heat shrinkable tubing to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.
- F. Entering Structures:
 - 1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.

3.06 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 8 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze supported conduit, allow 25 percent extra space for future conduit.

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- C. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 - 1. Wood: Wood screws.
 - 2. Hollow Masonry Units: Toggle bolts.
 - 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 - 4. Steelwork: Machine screws.
 - 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.
- D. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.
- E. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.07 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
- C. Install with symmetrical bends or cast metal fittings.
- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

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G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.08 EXPANSION/DEFLECTION FITTINGS

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

3.09 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

3.10 PVC-COATED RIGID STEEL CONDUIT

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

3.11 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

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B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

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

3.12 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.

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7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Supports:

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

3.13 EMPTY RACEWAYS

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

3.14 IDENTIFICATION DEVICES

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

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3.15 PROTECTION OF INSTALLED WORK

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

END OF SECTION

**SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS**

PART 1 GENERAL

1.01 REFERENCES

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

1.02 SUBMITTALS

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

1.03 QUALITY ASSURANCE

- A. Short circuit and protective device coordination and arc flash studies shall be prepared by manufacturer furnishing equipment or new equipment a professional electrical engineer registered in the State of Washington.

SALMON CREEK TREATMENT PLANT UV SYSTEM REPLACEMENT

1.04 SEQUENCING AND SCHEDULING

- A. Initial complete short circuit study shall be submitted and reviewed before Engineer will review Shop Drawings for distribution equipment.
- B. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.
- C. Initial complete arc flash study shall be submitted and accepted prior to energization of the electrical equipment.
- D. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 10 days before energizing electrical equipment.
- E. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.
- F. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

- A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on the Drawings.
- B. Perform studies using one of the following electrical engineering software packages: SKM Power Tools for Windows.
- C. Perform complete fault calculations for each proposed and ultimate source combination. Source combination may include present and future power company supply circuits, large motors, or generators.
- D. Utilize proposed and existing load data for study obtained from Contract Documents.
- E. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.

1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.
6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN conductors.
7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.
7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.
9. Zero-sequence impedance diagrams.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Branch circuit panelboards.
2. Future load contributions as shown on one-line diagram.

D. Verify:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of switchgear and motor control centers bus bars to withstand short circuit stresses.
3. Adequacy of transformer windings to withstand short circuit stresses.
4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

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E. Tabulations:

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

F. Written Summary:

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

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

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

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

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets:
 - a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
 - b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
 - c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
 - d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
 - e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Significant symmetrical and asymmetrical fault currents.
2. Ground fault protective device settings.

C. Tabulate Recommended Protective Device Settings:

1. Relays:
 - a. Current tap.
 - b. Time dial.
 - c. Instantaneous pickup.
 - d. Electronic settings data file.
2. Circuit Breakers:
 - a. Adjustable pickups.
 - b. Adjustable time-current characteristics.
 - c. Adjustable time delays.
 - d. Adjustable instantaneous pickups.
 - e. I^2t In/Out.
 - f. Zone interlocking.
 - g. Electronic settings data file.

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D. Written Summary:

1. Scope of studies performed.
2. Summary of protective device coordination methodology.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of coordination study.
6. Appendix of complete relay and circuit breaker electronic setting files, submit electronic data files from manufacturer's software.
7. Comments or suggestions.

1.08 ARC FLASH STUDY

- A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.
- B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.
- C. Base Calculation:
1. For each major part of electrical power system, determine the following:
 - a. Flash hazard protection boundary.
 - b. Limited approach boundary.
 - c. Restricted approach boundary.
 - d. Incident energy level.
 - e. Glove class required.
- D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.
1. Bus name.
 2. Bus voltage.
- E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:
1. Bus name.
 2. Upstream protective device name, type, and settings.
 3. Bus line-to-line voltage.

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

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

- A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV-resistant and weather-resistant labels. An example label can be found at the end of this section in Figure 1.

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UV SYSTEM REPLACEMENT

PART 3 EXECUTION

3.01 GENERAL

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

3.02 SUPPLEMENT

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

END OF SECTION

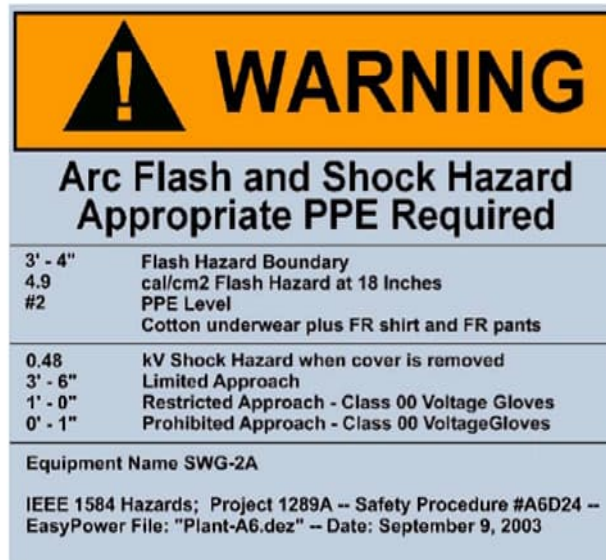


Figure 1
Example Arc Flash Label

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. D877/D877M, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - b. D923, Standard Practices for Sampling Electrical Insulating Liquids.
 - c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - f. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
 - j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43, Recommended Practice for Testing Insulation Resistance of Electric Machinery.
 - b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
 - c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
 - d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2,300V and Above) with High Direct Voltage.

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- e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above.
 - g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 - h. C2, National Electrical Safety Code.
 - i. C37.20.1, Standard for Metal-Enclosed Low-Voltage (1,000V ac and below, 3,200V dc and below) Power Circuit Breaker Switchgear.
 - j. C37.20.2, Standard for Metal-Clad Switchgear.
 - k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
 - l. C37.23, Standard for Metal-Enclosed Bus.
 - m. C62.33, Standard Test Methods and Performance Values for Metal-Oxide Varistor Surge Protective Components.
- 3. Insulated Cable Engineers Association (ICEA):
 - a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
 - b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
 - c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
 - b. PB 2, Deadfront Distribution Switchboards.
 - c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
 - 5. National Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 - 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70B, Recommended Practice for Electrical Equipment Maintenance.
 - c. 70E, Standard for Electrical Safety in the Workplace.
 - d. 101, Life Safety Code.
 - 7. National Institute for Certification in Engineering Technologies (NICET).
 - 8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
 - a. Testing firm qualifications.
 - b. Schedule for performing inspection and tests.
 - c. List of references to be used for each test.
 - d. Sample copy of equipment and materials inspection form(s).
 - e. Sample copy of individual device test form.
 - f. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
 - a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
 - b. Staged sequence of initial energization of electrical equipment.
 - c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
 - d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:
 - a. In accordance with Section 01 78 23, Operation and Maintenance Data.
 - b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings:
 - a. At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
 - 1) Protective relays.
 - 2) Intelligent overload relays.
 - 3) Adjustable frequency drives.
 - 4) Power metering devices.
 - 5) Uninterruptible power supplies.
 - 6) Electrical communications modules.

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test Instrument Calibration: In accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

1. Scheduled with Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Notify Owner at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.
- B. Tests and inspections shall establish:
 - 1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
 - 2. Installation operates properly.
 - 3. Equipment is suitable for energization.
 - 4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.
- C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.
- D. Set, test, and calibrate circuit breakers and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.
- E. Adjust mechanisms and moving parts of equipment for free mechanical movement.
- F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- G. Verify nameplate data for conformance to Contract Documents and approved Submittals.
- H. Realign equipment not properly aligned and correct unlevelness.
- I. Properly anchor electrical equipment found to be inadequately anchored.
- J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.
- K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

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- L. Provide proper lubrication of applicable moving parts.
- M. Inform Engineer of working clearances not in accordance with NFPA 70.
- N. Investigate and repair or replace:
 - 1. Electrical items that fail tests.
 - 2. Active components not operating in accordance with manufacturer's instructions.
 - 3. Damaged electrical equipment.
- O. Electrical Enclosures:
 - 1. Remove foreign material and moisture from enclosure interior.
 - 2. Vacuum and wipe clean enclosure interior.
 - 3. Remove corrosion found on metal surfaces.
 - 4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
 - 5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
 - 6. Repair or replace improperly operating latching, locking, or interlocking devices.
 - 7. Replace missing or damaged hardware.
 - 8. Finish:
 - a. Provide matching paint and touch up scratches and mars.
 - b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.
- P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

- A. Voltage Field Test:
 - 1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
 - 2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
- B. Equipment Line Current Tests:
 - 1. Check line current in each phase for each piece of equipment.
 - 2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.

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3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date Drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests:

1. Include the following items performed in accordance with manufacturer's instruction:
 - a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 2) Each phase of each bus section.
 - 3) Phase-to-phase and phase-to-ground for 1-minute.
 - 4) With breakers open.
 - 5) With switches closed.
 - 6) Control wiring except that connected to solid state components.
 - 7) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.04 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.

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3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.05 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

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

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- c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 - 3. Shielded Instrumentation Cables for:
 - a. Proper shield grounding.
 - b. Proper terminations.
 - c. Proper circuit identification.
 - 4. Control Cables for:
 - a. Proper termination.
 - b. Proper circuit identification.
 - 5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.
- B. Electrical Tests for Conductors No. 6 and Larger:
 - 1. Insulation Resistance Tests:
 - a. Utilize 1,000V dc megohmmeter for 600-volt insulated conductors and 500V dc megohmmeter for 300-volt insulated conductors.
 - b. Test each conductor with respect to ground and to adjacent conductors for 1-minute.
 - c. Evaluate ohmic values by comparison with conductors of same length and type.
 - d. Investigate values less than 50 megohms.
 - 2. Continuity test by ohmmeter method to ensure proper cable connections.
- C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.06 SAFETY SWITCHES, 600 VOLTS MAXIMUM

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

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B. Electrical Tests:

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

3.07 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:

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

C. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Utilize 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers.
 - b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
 - c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - d. Test values to comply with NETA ATS, Table 100.1.

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

3.08 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

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

B. Electrical Tests:

1. Fall-of-Potential Test:
 - a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
 - b. Main ground electrode system resistance to ground to be no greater than 5 ohm(s).

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2. Two-Point Direct Method Test:
 - a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
 - b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.09 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus and electrode.

B. Electrical Tests:

1. Varistor Type Arrestors:
 - a. Clamping voltage test.
 - b. Rated RMS voltage test.
 - c. Rated dc voltage test.
 - d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

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

1. Code of Federal Regulations (CFR): 10 CFR Part 431, DOE 2016 efficiency.
2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
3. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. ST 20, Dry-Type Transformers for General Applications.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. UL:
 - a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.
5. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Test Report: Sound test certification for dry type power transformers (0-volt to 600-volt, primary).
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

PART 2 PRODUCTS

2.01 GENERAL

- A. UL 1561, NEMA ST 20, unless otherwise indicated.
- B. Dry-type, self-cooled, two-winding, with aluminum windings.
- C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- D. Efficiency: Meet or exceed DOE 2016 efficiency requirements.
- E. Maximum Sound Level per NEMA ST 20:
 1. 40 decibels for 0 kVA to 9 kVA.
 2. 45 decibels for 10 kVA to 50 kVA.
 3. 50 decibels for 51 kVA to 150 kVA.
 4. 55 decibels for 151 kVA to 300 kVA.
 5. 60 decibels for 301 kVA to 500 kVA.
- F. Overload capability: Short-term overload per IEEE C57.96.
- G. Vibration Isolators:
 1. Rated for transformer's weight.
 2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
 3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
 4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

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H. Manufacturers:

1. Square D Co.
2. Eaton/Cutler-Hammer.

2.02 MINI-POWER CENTER (MPC)

A. General: Transformer, primary, and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 4X, 316 stainless steel enclosure.

B. Transformer:

1. Insulation Class and Temperature Rise: Manufacturer's standard.
2. Efficiency: Manufacturer's standard (DOE 2016 efficiency).
3. Core and Coil: Encapsulated.
4. Full capacity, 5 percent voltage taps, two below normal voltage.
5. Primary Voltage: 480, single-phase.
6. Secondary Voltage: 240/120 volts, single-phase, three-wire.

C. Panelboard: Full, UL 489, short-circuit current rated.

1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
2. Number and Breaker Ampere Ratings: Refer to Panel Schedule on the Drawings.

2.03 K-RATED TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.
115 degrees C temperature rise.

B. Core and Coil: Sized and configured to reduce overheating caused by harmonic components.

C. Enclosure: NEMA 250, Type 2 with weather shield for NEMA 3R rating.

D. Voltage Taps: Six 2.5 percent, full capacity; two above and four below normal voltage rating.

E. K Factor: K-13.

F. Neutral Bus and Terminal: 200 percent of rated current.

G. Electrostatic shield.

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PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with NECA and manufacturer's instructions.
- B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.
- C. Provide moisture-proof, flexible conduit for electrical connections.
- D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.
- E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
 2. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. 289, Application Guide for Ground Fault Circuit Interrupters.
 - c. KS 1, Enclosed Switches.
 - d. PB 1, Panelboards.
 - e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 4. UL:
 - a. 67, Standard for Panelboards.
 - b. 98, Standard for Enclosed and Dead-Front Switches.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
 - g. 943, Ground-Fault Circuit-Interrupters.
 - h. 1699, Standard for Arc-Fault Circuit-Interrupters.

1.02 SUBMITTALS

- A. Action Submittals:
1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
 2. Manufacturer's Shop Drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.

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3. Tabulation of features for each panelboard to include the following:
 - a. Protective devices with factory settings.
 - b. Provisions for future protective devices.
 - c. Space for future protective devices.
 - d. Voltage, frequency, and phase ratings.
 - e. Enclosure type.
 - f. Bus and terminal bar configurations and current ratings.
 - g. Provisions for circuit terminations with wire range.
 - h. Short circuit current rating of assembled panelboard at system voltage.
 - i. Features, characteristics, ratings, and factory settings of auxiliary components.
 - j. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.

1.03 QUALITY ASSURANCE

- A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
1. Eaton/Cutler-Hammer.
 2. Square D Co.
 3. Siemens.
- B. "Or-equal" or substitute products will be considered.

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2.02 GENERAL

- A. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.
- B. Wire Terminations:
 - 1. Provide panelboard assemblies, including protective devices, suitable for use with 75 degrees C or greater wire insulation systems at NFPA 70, 75 degrees C conductor ampacity, and in accordance with UL 486E.
 - 2. Lugs for termination of conductors shall comply with Section 26 05 05, Conductors.
 - 3. Lugs for termination of copper feeder phase and neutral conductors shall be replaceable, bolted crimp compression type only.
- C. Load Current Ratings:
 - 1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
 - 2. Where indicated "continuous" or "100 percent," selected components and protective devices shall be rated for continuous load current at value shown.
- D. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the fault current available as shown at point of application in distribution system.
- E. Series-Connected Short Circuit Current Ratings: Panelboards shall be fully rated, application of series-connected device ratings is unacceptable.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Overcurrent Device Mounting and Arrangement: Design panelboards to accommodate device installation and replacement without disturbing adjacent devices and without removing main bus.
- B. Overcurrent Protective Devices: In accordance with NEMA KS 1, UL 98, and UL 489. Protective devices shall be adapted to panelboard installation.

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C. Provisions for Future Overcurrent Device:

1. Provide space, mountings and bus connections such that like device may be installed without additional hardware.
2. Panel openings shall be closed with individual removable cover for each provision for future device.
3. Unless otherwise indicated, "spaces" in panelboards shall be fully equipped provision for future like devices.
4. Provisions for future devices shall be suitable devices rated no less than 60 amperes.

D. Branch Protective Devices:

1. Provide Wire Lug Load Connections: Removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
2. Provide a nameplate for each circuit, blanks for spares.

2.04 CIRCUIT BREAKERS

A. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle. Circuit breakers shall comply with Section 26 05 04, Basic Electrical Materials and Methods.

B. Bus Connection: Bolt-on circuit breakers in all panelboards.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.

D. Unacceptable Substitution:

1. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
2. Do not use tandem or dual circuit breakers in normal single-pole spaces.

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- E. Specialty Breakers: Where indicated, provide breakers with the following features:
1. Ground Fault Circuit Interrupter (GFCI): Rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel). Ground fault sensor shall be rated same as circuit breaker. Breaker shall include push-to-test and reset buttons.
 2. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).

2.05 ENCLOSURES

A. General:

1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Type 1, Type 3R, and Type 3S material code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Provide surface-mount panelboard from trim with same dimensions as box front.

- B. Finish: Rust inhibitor prime followed by manufacturer's standard gray baked enamel or lacquer.

C. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Secure front trim to box with concealed trim clamps.
2. Overlap flush panelboards front trims with box nominal 3/4-inch on all sides.
3. Provide door in panelboard front trim, with concealed hinges, to access protective device operating handles.
4. Provide multi-point latching for doors over 30 inches in height.
5. Door Lock: Secure with flush catch and tumbler lock, all panelboards keyed alike, with two milled keys each lock.
6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
7. Column-Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.
8. Hinged Front Cover (Door In Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

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PART 3 EXECUTION

3.01 GENERAL

- A. Install in accordance with NECA 407, NEMA PB 1.1, and manufacturers' written installation instructions.
- B. Install securely, plumb, in-line and square with walls.
- C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.
- D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.
- E. Install filler plates in unused spaces.
- F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.
- G. Mount flush panels uniformly flush with wall finish.
- H. Provide typewritten circuit directory for each panelboard.

END OF SECTION

SECTION 31 23 13
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 DEFINITIONS

- A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.
- B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, dewatering, excavation to grade, and scarification and compaction of subgrade.
- A. Proof-Rolling: Test rolling of subgrade by heavily load vehicle or roller to identify areas that will not support the future loading without excessive settlement or rutting.
- B. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.
- C. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil, and required excavations prior to placement of structural fill, roadway structure or base for floor slab.
- D. Unsuitable Material: Subgrade material unsuitable for the project consisting of rubble, debris, vegetation, and undocumented fill.

1.02 SEQUENCING AND SCHEDULING

- A. Complete applicable Work specified in Section 02 41 00, Demolition, Section 31 23 19.01, Dewatering, Section 31 41 00, Shoring, and Section 31 23 16, Excavation, prior to subgrade preparation.

1.03 QUALITY ASSURANCE

- A. Notify Owner's Representative when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.04 ENVIRONMENTAL REQUIREMENTS

- A. Prepare subgrade when unfrozen and free of ice and snow.

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PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.
- B. Bring subgrade to proper grade and cross-section and uniformly compact surface.
- C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.
- D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

- A. Under Earthfill: Three passes with three-wheeled power roller weighing approximately 10 tons.
- B. Under Pavement Structure, Floor Slabs on Grade, or Granular Fill Under Structures: Five passes with a three-wheeled power roller weighing approximately 10 tons.
- C. Subgrade rutting or pumping during compaction because of excessive water buildup, indicate that groundwater dewatering efforts or moisture conditioning efforts are ineffective. Discontinue compaction until requirements specified in Section 31 23 19.01, Dewatering, are met.

3.03 MOISTURE CONDITIONING

- A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.
- B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 TESTING

- A. In areas determined by the Engineer, proof-roll subgrade with equipment specified in Article Compaction to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

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3.05 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact.
2. Overexcavate as specified in Section 31 23 16, Excavation, and replace with Granular Fill as specified in Section 31 23 23, Fill and Backfill.

B. Unsuitable Material: Overexcavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

SECTION 31 23 16
EXCAVATION

PART 1 GENERAL

1.01 DEFINITIONS

- A. Common Excavation: Removal of material not classified as rock excavation.

1.02 SUBMITTALS

- A. Informational Submittals:

1. Excavation Plan, Detailing:
 - a. Methods and sequencing of excavation.
 - b. Proposed locations of stockpiled excavated material.
 - c. Proposed onsite and offsite spoil disposal sites.
 - d. Numbers, types, and sizes of equipment proposed to perform excavations.
 - e. Anticipated difficulties and proposed resolutions.
 - f. Restoration of onsite spoil disposal areas.
 - g. Design calculations demonstrating temporary cut slopes for excavations are stable such that no existing facilities or completed Work will be impacted.
 - h. Excavation Plan and design calculations shall be stamped by a professional engineer, licensed in the State of Washington.
 - i. Review of Excavation Plan shall only be for compliance with topics included preparation or performance by registered engineer, and similar specified requirements, and not for accuracy or adequacy of plan or facilities which shall be solely responsibility of the Contractor.
 - j. If less than 1 acre is disturbed at any one time, submit construction stormwater permit.
2. Required excavation permits from applicable governing agencies.

1.03 QUALITY ASSURANCE

- A. Provide adequate survey control to avoid unauthorized overexcavation.

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1.04 WEATHER LIMITATIONS

- A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.
- B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.05 SEQUENCING AND SCHEDULING

- A. Demolition: Complete applicable Work specified in Section 02 41 00, Demolition, prior to excavating.
- B. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.
- C. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.
- B. Do not excavate until existing facilities, including existing duct banks, utility vaults, control structures, and other necessary existing facility are fully supported or shored and prevented from any movement or subsidence during or after excavation.
- C. Do not overexcavate without written authorization of Engineer.
- D. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

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3.02 UNCLASSIFIED EXCAVATION

- A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.03 TRENCH WIDTH

- A. Minimum Width of Trenches:
 - 1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
 - a. Less than 4-inch Outside Diameter or Width: 18 inches.
 - b. Greater than 4-inch Outside Diameter or Width: 18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
 - 2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
 - 3. Increase trench widths by thicknesses of sheeting.
- B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 EMBANKMENT AND CUT SLOPES

- A. Remove loose stones and rock that exceed 3-inch diameter. Remove exposed roots from cut slopes.
- B. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

3.05 STOCKPILING EXCAVATED MATERIAL

- A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.
- B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.
- C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

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- D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.
- E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could cause damage by structural failure or settlement.

3.06 DISPOSAL OF SPOIL

- A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.
- B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00, Demolition, for demolition debris.

END OF SECTION

SECTION 31 23 19.01
DEWATERING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Water control plan.
2. Well permits.
3. Discharge permits – Coordinate with Owner and obtain authorization from plant staff for alternative discharge to plant drain.
4. Inflow Measurements: Submit weekly record.

1.02 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, means of measuring inflow to excavations, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system, including extraction wells, piezometers and observation wells, conveyance piping, pumps, sedimentation control facilities, discharge locations, and other components necessary to facilitate sufficient dewatering.
3. Design calculations demonstrating adequacy of proposed dewatering systems and components.
4. Water control plan and design calculations shall be stamped by professional engineer, licensed in the State of Washington.

B. If system is modified during installation or operation, revise or amend and resubmit Water Control Plan. Do not commence excavation until revised and amended Water Control Plan has been received.

C. Review of Contractor's Water Control Plan (original and any subsequent revisions) shall be only for compliance with specific stated requirements for its content and that it is stamped by a licensed engineer as specified and not for accuracy of content or for adequacy of the Plan, both of which shall be solely the responsibility of Contractor.

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PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

3.02 SURFACE WATER CONTROL

- A. See Section 01 50 00, Temporary Facilities and Controls, Article Temporary Controls.
- B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

- A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 5 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, including artesian and perched groundwater and until backfilled to final grade.
- B. Design and Operate Dewatering Systems:
 - 1. To prevent loss of ground as water is removed.
 - 2. To allow required compaction of subgrade.
 - 3. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
 - 4. To relieve artesian pressures and resultant uplift of excavation bottom.
 - 5. To allow excavation and construction of structures free of water.
 - 6. To prevent instability of faces of excavation.
- C. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.
- D. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.
- E. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

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3.04 MONITORING FLOWS

- A. Monitor volume of water pumped each calendar day from wells, well points, and excavations. Also monitor volume of water introduced each day into excavations for performance of Work. Monitor flows using measuring devices acceptable to Engineer.

3.05 DISPOSAL OF WATER

- A. Obtain discharge permit for water disposal from authorities having jurisdiction.
- B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.
- C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.
- D. Remove and dispose of solids from treatment facilities per federal, state, and local regulations and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.06 PROTECTION OF PROPERTY

- A. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

END OF SECTION

SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
 - b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
 - c. D75, Standard Practice for Sampling Aggregates.
 - d. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-lbf/feet³ (2,700 kN-m/m³)).
 - e. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - f. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - g. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

- A. Completed Course: A course or layer that is ready for next layer or next phase of Work.
- B. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.
- C. Geosynthetics: Geotextiles, geogrids, or geomembranes.
- D. Imported Material: Materials obtained from sources offsite, suitable for specified use.

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- E. Influence Area:
 - 1. Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
 - a. 1 foot outside outermost edge at base of foundations or slabs.
 - b. 1 foot outside outermost edge at surface of roadways or shoulder.
 - c. 0.5 foot outside exterior at spring line of pipes or culverts.
- F. Lift: Loose (uncompacted) layer of material.
- G. Optimum Moisture Content:
 - 1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
 - 2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.
- H. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.
- I. Relative Compaction:
 - 1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
 - 2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.
- J. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.
- K. Structural Fill: Fill materials as required under structures, pavements, and other facilities.
- L. Well-Graded:
 - 1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
 - 2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
 - 3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

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1.03 SUBMITTALS

A. Action Submittals:

1. Certified test results from independent testing agency.
2. Shop Drawings: Tank manufacturer's recommendations for backfill around each buried tank.

B. Informational Submittals: Manufacturer's data sheets for compaction equipment.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure or tank is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.05 SEQUENCING AND SCHEDULING

- A. Complete applicable Work specified in Section 02 41 00, Demolition, Section 31 23 16, Excavation, and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.
- B. Backfill against concrete structures only after concrete has attained.
- C. Compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete. Obtain Engineer's acceptance of concrete work and attained strength prior to placing backfill.
- D. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, Cast-in-Place Concrete.
- E. Backfill around buried tanks only after tank is set in position, securely anchored, and ready to be backfilled, and Engineer provides authorization to backfill.
- F. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

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PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

- A. Gradation Tests: As necessary to locate acceptable sources of imported material.

2.02 EARTHFILL

- A. Excavated material from required excavations free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.
- B. Provide imported material of equivalent quality, if required to accomplish Work.

2.03 GRANULAR FILL

- A. 1-Inch minus crushed gravel or crushed rock.
- B. Free from dirt, clay balls, and organic material.
- C. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 8 percent by weight passing No. 200 sieve.

2.04 GRANULAR DRAIN MATERIAL

- A. As specified in Section 31 23 23.15, Trench Backfill.

2.05 WATER FOR MOISTURE CONDITIONING

- A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.06 FOUNDATION STABILIZATION ROCK

- A. Crushed rock or pit run rock.
- B. Uniformly graded from coarse to fine.
- C. Free from excessive dirt and other organic material.
- D. Maximum 2-1/2-inch particle size.

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2.07 CRUSHED ROCK FOR SUBSTATIONS

- A. Clean, hard, durable crushed rock, free from foreign materials and washed.
- B. Gradation as determined in accordance with ASTM C117 and ASTM C136.
- C. Base Course:

<u>Sieve Size</u>	<u>Percent Passing by Weight</u>
2 inches	-100
1-1/2 inches	95 - 100
3/4-inch	55 - 75
1/4-inch	35 - 50
No. 10	4 - 60

- D. Finish Grade Rock:

<u>Sieve Size</u>	<u>Percent Passing by Weight</u>
2 inches	-100
1-1/2 inches	90 - 100
1-inch	30 - 65
3/4-inch	0 - 15

- E. Access Road Surfacing: Gradation same as for base course.

PART 3 EXECUTION

3.01 GENERAL

- A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.
- B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.
- C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

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- D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.
- E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:
 - 1. Fill or backfill to an elevation 2 feet above top of item to be laid.
 - 2. Excavate trench for installation of item.
 - 3. Install bedding, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
 - 4. Install item.
 - 5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.
- F. Tolerances:
 - 1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
 - 2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.
- G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

- A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with 12 inches minimum of granular fill, unless otherwise shown. Place granular fill in lifts of 8-inch maximum thickness and compact each lift to minimum of 95 percent relative compaction as determined in accordance with ASTM D1557.
- B. Other Areas, outside of influence of structures, pavements, utilities: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 8-inch maximum thickness and compact each lift to minimum 90 percent relative compaction as determined in accordance with ASTM D1557.

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3.03 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM D6938. During placement of materials, test as follows:

1. Granular Fill: Three tests every other lift.

3.04 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows:

1. Beneath Footings: Concrete of strength equal to that of respective footing, as specified in Section 03 30 00, Cast-in-Place Concrete.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Granular fill.
4. Trenches:
 - a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.15, Trench Backfill.
 - b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.
5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
 - a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
 - b. Steep Slopes (Steeper than 3:1):
 - 1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.

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- 2) Backfilling overexcavated areas is prohibited, unless in Engineer's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.

END OF SECTION

SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

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

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
 - a. C33/C33M, Standard Specification for Concrete Aggregates.
 - b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
 - d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - e. C150/C150M, Standard Specification for Portland Cement.
 - f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
 - h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-lbf/feet³ (600 kN-m/m³)).
 - i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
 - j. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 feet-lbf/feet³ (2,700 kN-m/m³)).
 - k. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - l. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - m. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - n. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - o. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

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1.02 DEFINITIONS

- A. Base Rock: Granular material upon which manhole bases and other structures are placed.
- B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.
- C. Imported Material: Material obtained by Contractor from source(s) offsite.
- D. Lift: Loose (uncompacted) layer of material.
- E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.
- F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.
- G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D1557. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.
- H. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.
- I. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:
 - 1. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
 - 2. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.

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1.03 SUBMITTALS

A. Action Submittals:

1. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.
2. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.
3. Shop Drawings: Manufacturer's descriptive literature for marking tapes.

B. Informational Submittals: Catalog and manufacturer's data sheets for compaction equipment.

PART 2 PRODUCTS

2.01 MARKING TAPE

A. Nondetectable:

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 5 mils.
3. Width: 6 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
 - a. Reef Industries; Terra Tape.
 - b. Mutual Industries; Non-detectable Tape.
 - c. Presco; Non-detectable Tape.

B. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 6 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.

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7. Manufacturers and Products:
 - a. Reef Industries; Terra Tape, Sentry Line Detectable.
 - b. Mutual Industries; Detectable Tape.
 - c. Presco; Detectable Tape.

C. Color: In accordance with APWA Uniform Color Code.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.02 BEDDING MATERIAL AND PIPE ZONE MATERIAL

- A. Unfrozen, friable, and no clay balls, roots, or other organic material.
- B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.
 1. Duct Banks: 3/4-inch maximum particle size.
 2. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
 3. Pipe Under 18-Inch Diameter: 3/4-inch maximum particle size, except 1/4-inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3-inch diameter.
 4. Pipe 18-Inch Diameter and Greater: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe.
 5. Perforated Pipe: Granular drain material.
 6. Conduit and Direct-Buried Cable:
 - a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
 - b. Individual Particles: Free of sharp edges.
 - c. Maximum Size Particle: Pass a No. 4 sieve.

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- d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.03 EARTH BACKFILL

- A. Soil, loam, or other excavated material suitable for use as backfill.
- B. Free from roots or organic matter, refuse, boulders and material larger than 3 inches, or other deleterious materials.

2.04 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

- A. Select and proportion ingredients to obtain compressive strength between 50 pounds per square inch and 150 pounds per square inch at 28 days in accordance with ASTM D4832.
- B. Materials:
 - 1. Cement: ASTM C150/C150M, Type I or Type II.
 - 2. Aggregate: ASTM C33/C33M, Size 7.
 - 3. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
 - a. ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
 - 4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.05 SOURCE QUALITY CONTROL

- A. Perform gradation analysis in accordance with ASTM C136 for bedding and pipe zone material.
- B. Certify Laboratory Performance of Mix Designs: Controlled low strength material.

PART 3 EXECUTION

3.01 TRENCH PREPARATION

- A. Water Control:
 - 1. As specified in Section 31 23 19.01, Dewatering.
 - 2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
 - 3. Provide continuous water control until trench backfill is complete.

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- B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM

- A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.
- B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required.

3.03 BEDDING

- A. Furnish imported bedding material where, in the opinion of Engineer, excavated material is unsuitable for bedding or insufficient in quantity.
- B. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.
- C. Hand grade and compact each lift to provide a firm, unyielding surface.
- D. Minimum Thickness. As follows:
 - 1. Pipe 15 Inches and Smaller: 4 inches.
 - 2. Pipe 18 Inches to 36 Inches: 6 inches.
 - 3. Pipe 42 Inches and Larger: 8 inches.
 - 4. Conduit: 3 inches.
 - 5. Direct-Buried Cable: 3 inches.
 - 6. Duct Banks: 3 inches.
- E. Check grade and correct irregularities in bedding material. Loosen top 1-inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.
- F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.
- G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.04 BACKFILL PIPE ZONE

- A. Upper limit of pipe zone shall not be less than following:
 - 1. Pipe: 12 inches, unless shown otherwise.
 - 2. Conduit: 3 inches, unless shown otherwise.
 - 3. Direct-Buried Cable: 3 inches, unless shown otherwise.
 - 4. Duct Bank: 3 inches, unless shown otherwise.
- B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.
- C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.
 - 1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter.
 - 2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.
- D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.
- E. Do not use power-driven impact compactors to compact pipe zone material. After full depth of pipe zone material has been placed as specified, compact material by a minimum of three passes with a vibratory plate compactor only over area between sides of pipe and trench walls. Take care to avoid damaging pipe and pipe coating.

3.05 MARKING TAPE INSTALLATION

- A. Continuously install marking tape along centerline of buried piping, on top of last lift of pipe zone material Coordinate with Piping Installation Drawings.
 - 1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
 - 2. Nondetectable Marking Tape: Install with metallic piping.

3.06 BACKFILL ABOVE PIPE ZONE

- A. General:
 - 1. Process excavated material to meet specified gradation requirements.
 - 2. Adjust moisture content as necessary to obtain specified compaction.

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3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for.
7. adjacent trench, unless otherwise shown or specified.

B. Controlled Low Strength Material:

1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
3. In traveled areas fill entire trench section to pavement finish grade for a temporary driving surface, and screed off excess and finish with a float.

3.07 MAINTENANCE OF TRENCH BACKFILL

- A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.
- B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.
- C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.
- D. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.08 SETTLEMENT OF BACKFILL

- A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION

SECTION 31 41 00
SHORING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation support plan.
2. Movement monitoring plan.
3. Trench excavation plan.
4. Movement measurement and data and reduced results indicating movement trends.
5. Review of excavation support plan, movement monitoring plan, and trench excavation plan shall be only for compliance with topics included preparation or performance by a registered professional, and similar specified requirements, and not for the accuracy or the adequacy of the plans or facilities, which together with all other matters of health and safety shall be solely the responsibility of Contractor.

1.02 QUALITY ASSURANCE

- A. Perform surveys to monitor movements of existing structures, utilities and other facilities located within 100 feet of excavation.
- B. Perform surveys by professional land surveyor licensed in the State of Washington.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

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3.02 EXCAVATION SUPPORT PLAN AND TRENCH EXCAVATION PLAN

- A. Prepare excavation support and trench excavation plan addressing following topics:
1. Details of shoring, bracing, sloping, or other provisions for protection of existing facilities, finished products, and worker protection from hazards of caving ground.
 2. Design assumptions and calculations.
 3. Methods and sequencing of installing excavation support.
 4. Proposed locations of stockpiled excavated material.
 5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
 6. Anticipated difficulties and proposed resolutions.
 7. Excavation support plan and trench excavation plan shall be stamped and signed by a professional engineer licensed in the State of Washington.

3.03 MOVEMENT MONITORING PLAN

- A. Prepare movement monitoring plan addressing following topics:
1. Survey control.
 2. Location of monitoring points.
 3. Plots of data trends.
 4. Interval between surveys.
 5. Stamped and signed movement monitoring plan by a professional engineer licensed in the State of Washington.

3.04 REMOVAL OF EXCAVATION SUPPORT

- A. Remove excavation support in a manner that will maintain support as excavation is backfilled.
- B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.
- C. Remove excavation support in a manner that does not leave voids in the backfill.

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3.05 TRENCHES

- A. Provide trench excavations exceeding 4 feet in depth with adequate safety systems meeting the requirements of the Washington Industrial Safety and Health Act, Chapter 49.17 RCW.

END OF SECTION

SECTION 32 11 23
AGGREGATE BASE COURSE

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. C29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.
 - b. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
 - c. C117, Standard Method of Test for Materials Finer Than 75µm (No. 200) Sieve in Mineral Aggregates by Washing.
 - d. C131, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - e. C183, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
 - f. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-lb/feet³ (600 kN-m/m³)).
 - g. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³ (2700 kN-m/m³)).
 - h. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
 - i. D2216, Standard Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
 - j. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - k. D2844, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
 - l. D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
 - m. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
 - n. D5195, Standard Test Methods for Density of Soil and Rock In-Place Below Surface by Nuclear Methods.

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- o. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

- A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.
- B. Completed Lift: Compacted with uniform cross-section thickness.
- C. Standard Specifications: When referenced in this section, shall mean 2025 Standard Specifications for Road, Bridge and Municipal Construction, Washington State Department of Transportation.

1.03 SUBMITTALS

- A. Informational Submittals:
 - 1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.
 - 2. Certified results of in-place density tests from independent testing agency.

PART 2 PRODUCTS

2.01 BASE COURSE

- A. Crushed surfacing base course meeting all the requirements of Section 9.03.10 of the Standard Specifications.

2.02 LEVELING COURSE AND GRAVEL SURFACING

- A. Crushed surfacing top course meeting all the requirements of Section 9.03.10 of the Standard Specifications.

2.03 SOURCE QUALITY CONTROL

- A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.
- B. Final approval of aggregate material will be based on test results of installed materials.
- C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

- A. As specified in Section 31 23 13, Subgrade Preparation.
- B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.
- C. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

- A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

- A. Hauling Materials:
 - 1. Do not haul over surfacing in process of construction.
 - 2. Loads: Of uniform capacity.
 - 3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

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B. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Aggregate Base Course:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.
5. Add keystone to achieve compaction and as required when aggregate does not compact readily because of lack of fines or natural cementing properties, as follows:
 - a. Use leveling course or surfacing material as keystone.
 - b. Spread evenly on top of base course, using spreader boxes or chip spreaders.
 - c. Roll surface until keystone is worked into interstices of base course without excessive displacement.
 - d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

B. Leveling Course:

1. Maximum Completed Lift Thickness: 4 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on roadway or preceding course to depth, grade, and cross-section shown.
4. Lightly blade surface and roll until thoroughly compacted to line and grade shown.
5. Maintain moisture levels to prevent loss of fines during processing.

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C. Gravel Surfacing:

1. Maximum Completed Lift Thickness: 9 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on preceding course in accordance with cross-section shown.
4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

- A. Commence compaction of each layer of after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by ASTM D1557.
- B. Roll each layer of material until material does not creep under roller before succeeding layer is applied.
- C. Commence rolling at outer edges and continue toward center; do not roll center of road first.
- D. Apply water as needed to obtain specified densities.
- E. Place and compact each lift to the required density before succeeding lift is placed.
- F. Remove floating or loose stone from surface of preceding course before placing leveling course.
- G. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.
- H. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.06 SURFACE TOLERANCES

- A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.
- B. Finished Surface of Untreated Aggregate Base and Leveling Course: Within plus or minus 0.04-foot of grade shown at any individual point.
- C. Gravel Surfacing: Within 0.04-foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

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- D. Overall Average: Within plus or minus 0.01-foot from crown and grade specified.

3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Provide Engineer at least 2 hours advance notification prior to testing.
2. Show proof that areas meet specified requirements before requesting that Engineer identify density test locations.
3. Minimum sampling and testing requirements for aggregate base course and surfacing shall be by ASTM D2922 or ASTM D1556 at the locations directed by Engineer at the following frequency. Additional tests to verify compaction in areas that fail initial testing shall be at no additional cost to Owner.
 - a. Base Course: One per lift for every 1,500 square feet of surface area.

3.08 CLEANING

- A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

SECTION 32 12 16
ASPHALT PAVING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
 - b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
 - c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
 - d. M140, Standard Specification for Emulsified Asphalt.
 - e. M156, Standard Specification for Requirements for Mixing Plants for Hot-mixed, Hot-laid Bituminous Paving Mixes.
 - f. M208, Standard Specification for Cationic Emulsified Asphalt.
 - g. R35, Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt.
 - h. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
 - i. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
 - j. T209, Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA).
 - k. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
 - l. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus.
 - m. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
 - n. T283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage.

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- o. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.
 - p. T312, Standard Method of Test for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyratory Compactor.
 - 2. Asphalt Institute (AI):
 - a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
 - b. Superpave Series No. 2 (SP-2), Superpave Mix Design.
 - 3. ASTM International (ASTM):
 - a. D75, Standard Method of Test for Sampling of Aggregates.
 - b. D140, Standard Method of Test for Sampling Bituminous Materials.
 - c. D979, Standard Method of Test for Sampling Bituminous Paving Mixtures.
 - d. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
 - e. D2489, Standard Method of Test for Determining Degree of Particle Coating of Asphalt Mixtures.
 - f. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - g. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
 - h. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
 - i. E329, REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.

1.02 DEFINITIONS

- A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.
- B. Reclaimed Asphalt Pavement (RAP): Removed and/or processed pavement materials containing binder and aggregate.
- C. Standard Specifications: As defined in 2025 Standard Specifications for Road, Bridge, and Municipal Construction, Washington State Department of Transportation.

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

1.03 SUBMITTALS

A. Informational Submittals:

1. Asphalt Concrete Mix Formula:

- a. Submit minimum of 15 days prior to start of production.
- b. Submittal to include the following information:
 - 1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
 - 2) Bulk specific gravity for each aggregate constituent.
 - 3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
 - 4) Properties as stated in Section 5-04 of the Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
 - 5) Percent of asphalt lost due to absorption by aggregate.
 - 6) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
 - 7) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
 - 8) Optimum mixing temperature.
 - 9) Optimum compaction temperature.
 - 10) Temperature-viscosity curve of asphalt cement to be used.
 - 11) Brand name of any additive to be used and percentage added to mixture.

- B. Mix formula approved by Washington Department of Transportation for the current paving season may be submitted in lieu of establishing a job mix formula for this project, provided the job mix formula meets the requirements specified herein. Perform additional supplemental testing as necessary to meet all the requirements.

1. Test Report for Asphalt Cement:

- a. Submit minimum 10 days prior to start of production.
- b. Show appropriate test method(s) for each material and the test results.

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2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following materials:
 - a. Aggregate: Gradation, source test results as defined in Section 9-03.1(2) of the Standard Specifications.
 - b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
 - c. Prime Coat: Type and grade of asphalt.
 - d. Tack Coat: Type and grade of asphalt.
 - e. Additives.
 - f. Mix: Conforms to job-mix formula.
3. Statement of qualification for independent testing laboratory.
4. Test Results:
 - a. Mix design.
 - b. Asphalt concrete core.
 - c. Gradation and asphalt content of uncompacted mix.
 - d. Field density.
 - e. Quality control.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329, Rev. A.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

1.05 ENVIRONMENTAL REQUIREMENTS

- A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 50 degrees F (10 degrees C) or air temperature is lower than 40 degrees F (4 degrees C). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.
- B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tack Coat:

1. Emulsified Asphalt for Tack Coat or Seal Coat: Grade CSS-1, conform to Section 9-02.1(6) of the Standard Specifications.

B. Sand for Blotter Material or Sand Seal: Clean, dry, with 100 percent passing No. 4 (4.75-mm) sieve, and a maximum of 10 percent passing No. 200 (75 µm) sieve.

2.02 ASPHALT CONCRETE MIX

A. General:

1. Mix formula shall not be modified except with written approval of Engineer.
2. Source Changes:
 - a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
 - b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Engineer to confirm that properties are in compliance with design criteria.
 - c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Asphalt Concrete: Superpave mix design for up to three million ESALs meeting all the requirements of Section 9-03.8 of the Standard Specifications. Surface course shall be HMA Class 1/2-inch and base course shall be HMA Class 1-inch.

C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

D. Aggregate:

1. General: Class HMA 1/2-inch as specified in Section 9-03.8 of the Standard Specifications.

E. Mineral Filler: In accordance with AASHTO M17.

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UV SYSTEM REPLACEMENT

- F. Asphalt Cement: Paving Grade PG 64-22, as specified in Section 9-02.1(4) of the Standard Specifications.

PART 3 EXECUTION

3.01 GENERAL

- A. Traffic Control:
 - 1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
 - 2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

3.02 LINE AND GRADE

- A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.
- B. Shoulders: Construct to line, grade, and cross-section shown.

3.03 PREPARATION

- A. Prepare subgrade as specified in Section 31 23 13, Subgrade Preparation.
- B. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

3.04 PAVEMENT APPLICATION

- A. General: Place asphalt concrete mixture on approved, prepared base in conformance with this section.
- B. Tack Coat:
 - 1. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
 - 2. Do not apply more tack coat than necessary for the day's paving operation.
 - 3. Touch up missed or lightly coated surfaces and remove excess material.
 - 4. Application Rate: Minimum 0.25 liter to maximum 0.70 liter of asphalt (residual if diluted emulsified asphalt) per square meter (0.05 gallon per square yard to 0.15 gallon per square yard) of surface area.

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C. Pavement Mix:

1. Prior to Paving:
 - a. Sweep primed surface free of dirt, dust, or other foreign matter.
 - b. Patch holes in primed surface with asphalt concrete pavement mix.
 - c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in two equal lifts.
3. Compacted Lift Thickness:
 - a. Minimum: Twice maximum aggregate size, but in no case less than 1-inch (25 mm).
 - b. Maximum: 4 inches (100 mm).
4. Total Compacted Thickness: As shown.
5. Sequence placement so that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
 - a. Offset edge of each layer a minimum of 6 inches (150 mm) so joints are not directly over those in underlying layer.
 - b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
 - c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 6 inches (150 mm) on each side of joint with cutback or emulsified asphalt. Cover immediately with sand.

D. Compaction:

1. Uniformly compact each course until no further evidence of consolidation is visible and roller marks are eliminated. When placement rate exceeds 100 tons (90 mg) per hour, operate minimum of two rollers for compaction.
2. Joint Compaction:
 - a. Place top or wearing layer as continuously as possible.
 - b. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.

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UV SYSTEM REPLACEMENT

- c. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
- d. Cut away waste material and lay new mix against fresh cut.

E. Tolerances:

- 1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
- 2. Completed Surface or Wearing Layer Smoothness:
 - a. Uniform texture, smooth, and uniform to crown and grade.
 - b. Maximum Deviation: 1/8-inch (3 mm) from lower edge of a 12-foot (3.6-meter) straightedge, measured continuously parallel and at right angle to centerline.
 - c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
- 3. Transverse Slope Maximum Deviation: 1/4-inch (6 mm) in 12 feet (3.6 meters) from rate of slope shown.
- 4. Finished Grade:
 - a. Perform field differential level survey on maximum 50-foot (15-meter) grid and along grade breaks.
 - b. Maximum Deviation: 0.02-foot (6 mm) from grade shown.

F. Seal Coat:

- 1. General: Apply seal coat of paving grade or emulsified asphalt to finished surface at longitudinal and transverse joints, joints at abutting pavements, areas where asphalt concrete was placed by hand, patched surfaces, and other areas as directed by Engineer.
- 2. Preparation:
 - a. Surfaces that are to be sealed shall be maintained free of holes, dry, and clean of dust and loose material.
 - b. Seal in dry weather and when temperature is above 35 degrees F (2 degrees C).
- 3. Application:
 - a. Fill cracks over 1/16-inch (1.5 mm) in width with asphalt-sand slurry or approved crack sealer prior to sealing.
 - b. When sealing patched surfaces and joints with existing pavements, extend minimum 6 inches (150 mm) beyond edges of patches.

3.05 PATCHING

A. Preparation:

1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.
2. Prepare patch subgrade as specified in Section 31 23 13, Subgrade Preparation.

B. Application:

1. Patch Thickness: 3 inches (75 mm) or thickness of adjacent asphalt concrete, whichever is greater.
2. Place asphalt concrete mix across full width of patch in layers of equal thickness.
3. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

C. Compaction:

1. Roll patches with power rollers capable of providing compression of 200 pounds per linear inch to 300 pounds per linear inch (350 Newtons per linear centimeter to 525 Newtons per linear centimeter). Use hand tampers where rolling is impractical.
2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least one-half the roller width. Progress toward center of patch overlapping each preceding track by at least one-half width of roller.
3. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.

D. Tolerances:

1. Finished surface shall be flush with and match grade, slope, and crown of adjacent surface.
2. Tolerance: Surface smoothness shall not deviate more than plus 1/4-inch (6 mm) or minus 0-inch when straightedge is laid across patched area between edges of new pavement and surface of old surfacing.

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3.06 FIELD QUALITY CONTROL

- A. General: Provide services of approved certified independent testing laboratory to conduct tests.
- B. Field Density Tests:
 - 1. Perform tests from cores or sawed samples in accordance with AASHTO T166.
 - 2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
 - 3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.
- C. Testing Frequency:
 - 1. Quality Control Tests:
 - a. Asphalt Content, Aggregate Gradation: Once per every 200 tons (400 mg) of mix or once every 4 hours, whichever is greater.
 - b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 500 tons (900 mg) or once every 8 hours, whichever is greater.
 - 2. Density Tests: Once every 200 tons (450 mg) of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO).
 - a. M6, Standard Specification for Fine Aggregate for Portland Cement Concrete.
 - b. M80, Standard Specification for Coarse Aggregate for Portland Cement Concrete.
 - c. M153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
 - d. M157, Standard Specification for Ready-Mixed Concrete.
 - e. M213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
 - f. M227/M227M, Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties.
 2. American Concrete Institute (ACI):
 - a. 305R, Hot Weather Concreting.
 - b. 306R, Cold Weather Concreting.
 - c. 308, Standard Practice for Curing Concrete.
 - d. 318/318R, Building Code Requirements for Structural Concrete and Commentary.
 - e. 325.9R, Guide for Construction of Concrete Pavements and Concrete Bases.
 3. ASTM International (ASTM):
 - a. A615/A615M, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - c. C33, Specification for Concrete Aggregates.
 - d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

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- f. C78, Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
- g. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
- h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
- i. C143/C143M, Standard Test Method for Slump of Hydraulic Cement Concrete.
- j. C150, Specification for Portland Cement.
- k. C172, Standard Practice for Sampling Freshly Mixed Concrete.
- l. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
- m. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
- n. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- o. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
- p. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
- q. C803/C803M, Test Method for Penetration Resistance of Hardened Concrete.
- r. C1330, Specification for Cylindrical Seal Backing for Use With Cold Liquid Applied Sealants.
- s. C805, Test Method for Rebound Number of Hardened Concrete.
- t. D920, Standard Specification for Elastomeric Joint Seals.
- u. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
- v. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
- w. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
- x. D2628, Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete.
- y. D2828, Specification for Non-Bituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type.
- z. D3406, Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements.
- aa. D3569, Specification for Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant Type for Portland Cement Concrete Pavements.

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- bb. D3581, Specification for Joint Sealant, Hot-Applied, Jet-Fuel-Resistant-Type, for Portland Cement and Tar-Concrete Pavements.
- cc. D5249, Specification for Backer Material for Use With Cold- and Hot-Applied Joint Sealants in Portland Cement Concrete and Asphalt Joints.
- dd. D5893, Specification for Cold-Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
- ee. E329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
- 4. National Ready Mixed Concrete Association (NRMCA).

1.02 DEFINITIONS

- A. Standard Specification: As defined in 2025 Standard Specifications for Road, Bridge, and Municipal Construction, Washington State Department of Transportation.

1.03 SUBMITTALS

- A. Provide as required in Section 03 30 00, Cast-in-Place Concrete.

1.04 QUALITY ASSURANCE

- A. Provide as required in Section 03 30 00, Cast-in-Place Concrete.
- B. Hot Weather Concreting: Conform to ACI 305R.
- C. Cold Weather Concreting: Conform to ACI 306R.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Transporting of ready-mix concrete shall be in accordance with ASTM C94/C94M.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

- A. Cement:
 - 1. Furnish cement for Project from one source.
 - 2. Provide as required in Section 03 30 00, Cast-in-Place Concrete.
 - 3. In accordance with ASTM C150.
 - 4. Pozzolan as specified in Section 03 30 00, Cast-in-Place Concrete.

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- B. Aggregates:
 - 1. General: As specified in Section 03 30 00, Cast-in-Place Concrete.
 - 2. Fine Aggregates: Gradation as specified in Section 9-03.1 of the Standard Specifications.
 - 3. Coarse Aggregate: Gradation as specified in Section 9-03.1(4) of the Standard Specifications.
- C. Physical Properties: In accordance with Section 9-03.1 of the Standard Specifications.
- D. Water: ASTM C94/C94M.
- E. Admixtures:
 - 1. Add admixtures to mix at batch plant.
 - 2. Air Entraining: ASTM C260.
 - 3. Water Reducing:
 - a. ASTM C494/C494M, Type A, normal, containing no chlorides and compatible with air-entraining admixtures.
 - b. Do not use calcium chloride, salt, or antifreeze agents.

2.02 ANCILLARY MATERIALS

- A. Tie Bars: Grade 40 deformed steel bars conforming to Section 03 21 00, Steel Reinforcement.
- B. Dowels: Conform to requirements of AASHTO M227/M227M, Grade 70.
- C. Joint Sealant:
 - 1. Preformed elastomeric joint seal conforming to AASHTO M220.
 - 2. Hot-poured elastomeric joint seal conforming to AASHTO M282.
 - 3. Cold-applied single component joint sealant conforming to ASTM D5893.
 - 4. Elastomeric joint sealant conforming to ASTM C920.
- D. Backer Rod:
 - 1. Backer material conforming to ASTM D5249.
 - 2. Cylindrical sealant backing conforming to ASTM C1330.
- E. Curing Compound: ASTM C309, Type 1, suitable for spray application.

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F. Curing Membranes:

1. White polyethylene sheeting.
2. Waterproof paper.
3. Cotton or jute mats.

G. Evaporation Retardant: Confirm as manufactured by Master Builders Company.

2.03 EQUIPMENT

A. Ready-Mix Concrete Batch Plants: Certified by NRMCA.

B. Batch Plants: Conform to requirements of Section 6-02.3(4)A of the Standard Specifications.

C. Ready-Mix Concrete Trucks:

1. Agitator mixer type.
2. Equipped with operable electrically actuated drum revolution counters.
3. Use of nonagitator equipment will not be permitted.
4. Each mixer shall carry a clearly visible manufacturer's plate showing capacity of mixer and other pertinent operating rates and limits.
5. Provision shall be made at mixer for controlled addition of air-entraining admixtures or other special components of mix.
6. Mixing Speed: 70 revolutions to 100 revolutions at a mixing speed recommended by truck mixer manufacturer.

D. Hauling Equipment: As specified in Section 6-02.3(4)A of the Standard Specifications.

E. Concrete Saws:

1. Provide power driven concrete saws for sawing joints or finishing concrete, adequate in number of units and power to complete sawing at required rate.
2. Saws and related equipment shall be of proven adequacy and design to perform efficiently and shall be subject to immediate replacement, if specified results are not obtained.
3. Standby saw shall be available at Site.

F. Smoothness Testing Equipment: Supply two 12-foot straightedges for determining smoothness.

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2.04 CONCRETE MIX DESIGN

- A. As specified in Section 03 30 00, Cast-in-Place Concrete, with a minimum flexural strength of 650 pounds per square inch.
- B. Concrete target strengths shall be in accordance with ACI 318/318R.
- C. If Contractor proposes to use a current mix design that meets these Specifications, has been used on previous WSDOT project, and less than 1 year has elapsed since it was last used; Contractor shall submit documentation of production of concrete produced from that mix design to Engineer for review. If review verifies concrete produced meets these Specifications and strength requirements, and establishes a correlation between compressive strength and flexural strength, no trial batches for proposed mix design will be required.

PART 3 EXECUTION

3.01 WEATHER LIMITATIONS

- A. Concrete shall not be placed:
 - 1. Until the air temperature in the shade is 35 degrees F and rising and is forecast to remain above 35 degrees F.
 - 2. On frozen ground.
 - 3. During periods of rain or snow.
- B. Concrete placement shall not continue when air temperature drops below 40 degrees F.
- C. Protect concrete pavement from inclement weather for 7 days after it has been placed, when rain is imminent, and when air temperature drops or is forecast to drop below 35 degrees F.

3.02 PREPARATION

- A. Prepare base as specified in Section 32 11 23, Aggregate Base Courses.
- B. Dampen base thoroughly prior to concrete placement; standing water will not be permitted.
- C. Formwork shall be complete prior to placement of concrete. Area in which concrete is to be placed, shall be smooth and free of ruts, projections, debris, spilled concrete, mud, sloughed soil, standing water, organic and other objectionable materials.

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- D. Construction Joints: Inspect prior to placement of concrete.
- E. Prior to placing paving equipment in position, full width and length of the area on which the tracks of the paving equipment is to operate shall be brought to density and surface tolerances required.
- F. Protect existing exposed surfaces such as grates, catch basins, air valves, manholes, and cleanout lids from splattered and spilled concrete during concrete placement by use of durable waterproof paper.
- G. Furnish operable backup vibrator on Site prior to concrete placement.

3.03 STATIONARY SIDE FORM CONSTRUCTION

- A. Where width of pavement is narrow, tapering, or of irregular pattern not lending itself to being constructed by prescribed machine methods, Contractor shall be permitted to Perform strike off, consolidation, final floating, and surface finishing with equipment, tools, means, labor, and methods other than those specified, provided the Work meets approval of Engineer and the following requirements:
 - 1. As concrete is being placed, striking off and consolidating portland cement concrete shall be done without causing segregation of material and shall include thorough uniform vibration throughout the mass until it is uniformly compacted.
 - 2. Portland cement concrete shall be struck off by means of templates or screeds designed and manipulated to shape portland cement concrete to specified cross section between forms, carrying a slight excess of portland cement concrete in front of leading edge of templates or screeds at all times. Tamp portland cement concrete to reduce voids to a minimum.
 - 3. Floating shall follow vibrating, striking off, and tamping operations and shall include transverse floating or other smoothing and finishing action. This shall provide a surface and evenness within a 12-foot straightedge tolerance of 0.01-foot. Test hardened surface in presence of Engineer. Surface shall be free from laitance, soupy mortar, marks, or irregularities.

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B. Defects:

1. Fill areas of minor honeycomb or other minor defect in composition of portland cement concrete along exposed edges of portland cement concrete with a stiff mortar of cement and fine aggregate. Apply to moistened portland cement concrete to satisfaction of Engineer.
2. Area showing serious defects in composition of concrete shall be removed and replaced with pavement of specified quality for full width of strip between longitudinal joints or edges and for a length not less than between the nearest transverse joints.

3.04 JOINTS

A. General:

1. Referred to as contraction or construction, either of which may be transverse or longitudinal, as called for by Drawings or as approved by Engineer.
2. Joints, backer material, joint filler and joint sealants shall extend to pavement edges or to each other, as the case may be, and shall be constructed perpendicular to surface of pavement.
3. Joints shall not vary from specified or indicated line by more than 1/4-inch.
4. Contractor shall submit jointing plan and details to Engineer for approval. Take into consideration placement of joints in curb and gutter, at catch basins, and position of manholes and other large structures, as well as other limitations herein mentioned.
5. Place manhole or similar large structure in line of joint, or if impractical, isolate structure from pavement with premolded joint filler, 1/2-inch wide, conforming to AASHTO M213 and ASTM D1751.

B. Contraction Joints:

1. Sawed Type with Poured Filler:
 - a. Sawing shall be to a depth as shown on the Drawings with a maximum width of 1/4-inch and a minimum width of 1/8-inch, in straight lines as shown or as approved by Engineer.
 - b. Perform saw cuts as soon as portland cement concrete has set enough to permit sawing without tearing or raveling, before uncontrolled cracking results, and within 24 hours of placing portland cement concrete.
 - c. Saws may be single or tandem, as Contractor may elect, and shall be controlled by guides to true line.

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- d. Clean joints thoroughly of foreign matter before pouring approved rubber asphalt filler.
- e. Tops of joint filler shall be true to pavement cross section within 1/8-inch and shall be protected from damage by portland cement concrete operations.
- f. Areas containing uncontrolled cracks shall be removed and replaced.
- g. Restore curing agents broken or damaged by sawing operations.
2. Space longitudinal joints as shown on the Drawings at the interface between lanes, normally at intervals between 12 feet to 16 feet.
3. Transverse joints shall be as shown on the Drawings or as approved by Engineer, with intervals of 12 feet to 16 feet.

C. Construction Joints:

1. Construct when there is an interruption of longer 45 minutes in portland cement concrete placing operations or where specified.
2. Place parallel with intended contraction joint.
3. Tool both free edges of joints with 1/8-inch radius rounder to remove laitance and mortar resulting from finishing operations and to provide clean rounded edge. Tooling shall not form ridges on surface of concrete.
4. New portland cement concrete placed contiguous to joint shall conform to proportions and consistency of previously placed concrete.
5. Transverse Construction Joint:
 - a. Doweled type using No. 8 by 36-inch long dowels at 12-inch centers coated with plastic, grease, heavy oil, or other approved material that will neither bond with nor be harmful to operation at a depth of 1/2 the pavement thickness parallel to centerline.
 - b. If sufficient portland cement concrete has not been mixed at the time of interruption to place a construction joint at least 3 feet from a planned contraction joint, remove excess portland cement concrete back to a position to satisfactorily meet these criteria and to satisfaction of Engineer.
 - c. Fill joint which has opened to a width of 1/8-inch or greater during construction or maintenance periods with poured filler.
 - d. Do not construct within 3 feet of a transverse contraction joint.

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D. Scored Joints:

1. Configuration: 1/4-inch wide by 1/4-inch deep at locations indicated on the Drawings formed by tooling of concrete while it is still fresh.
2. Do not fill or seal.
3. Layout of joints shall be straight and true and shall not vary from indicated line by more than 1/4-inch.

3.05 SURFACE FINISHING

- A. Use temporary screeds. Wet screeding and jitterbugging shall not be permitted.
- B. Pavement shall have surface tolerance of 1/4-inch in 10 feet in accordance with ACI 325.9R.
- C. Salting, spreading of cement or cement and sand mixture to speed up hardening shall not be permitted.
- D. Exposed pavement edges shall be edged to a 1/2-inch radius and construction joints shall be edged to 1/8-inch radius after finishing. Edging shall not form ridges on pavement surface.
- E. Pavement shall be treated and protected by use of evaporation retardant applied in accordance with manufacturer's written instructions. Flat surfaces shall be treated immediately after screeding and floating or if time period greater than 15 minutes occurs between finishing operations.
- F. Pavement shall be screeded, floated, and given heavy nylon bristle-broomed skid-resistant surface.
 1. Broomed surface with hand broom or mechanical broom device to produce 1/16-inch to 1/8-inch deep striations oriented perpendicular to the direction of travel.

3.06 CURING OF PORTLAND CEMENT CONCRETE

- A. Immediately after the final floating, surface finishing, and edging has been completed, and while portland cement concrete surface is still moist, cover and cure entire exposed surface for at least 72 hours in accordance with one of the following provisions:
 - 1. Liquid Membrane-Forming Compounds: Apply compound uniformly to portland cement concrete by pressure spray methods at a rate which will form an impervious membrane, but at least at a rate of 1-gallon per 150 square feet.
 - 2. Other Membranes:
 - a. Apply to damp portland cement concrete as soon as it can be placed without marring surface.
 - b. Place in contact with surface, extend beyond sides or edges of slabs or forms, and fasten down to hold it in position as a waterproof and moistureproof covering.
 - c. Laps shall be sufficient to maintain tightness equivalent to sheeting.
 - d. Transverse laps for waterproof paper shall be at least 18 inches, and longitudinal seams shall be cemented.
 - e. Cotton or jute mats shall be saturated with water prior to placing and kept fully wetted during curing period.
- B. Concrete shall be cured by use of curing compound, for minimum of 7 days after concrete placement, in accordance with ACI 308. Curing compounds shall be applied in accordance with manufacturer's written instructions.
- C. Exposed surfaces shall be sprayed with curing compound immediately after free surface water has disappeared from finished surface.
- D. Concrete temperature shall be maintained in accordance with ACI 306R.
- E. Curing compounds shall not come in contact with hardened concrete that is to be concreted against.

3.07 FIELD QUALITY CONTROL

- A. Retain independent testing or inspection agency to perform inspection, sampling, and testing.
- B. Concrete Sampling: In accordance with ASTM C172. Take sample not less than every 5,000 square feet or fraction thereof of concrete placed each day.

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- C. Perform following tests on each sampling:
 - 1. Slump: ASTM C143/C143M.
 - 2. Air Content: ASTM C231.
 - 3. Compressive Strength: ASTM C39/C39M.
 - 4. Flexural Strength: ASTM C78.
- D. Strength Tests:
 - 1. Make and cure cylinders and beams in accordance with ASTM C31/C31M.
 - 2. Cylinders: Make four, standard 6-inch diameter by 12 inches high. Cure one in field and three in laboratory.
 - 3. Beams: Make three, standard 6 inches by 6 inches by 21 inches. Cure in field.
 - 4. Compressive: Test one field-cured cylinder at 7 days and two laboratory-cured cylinders at 28 days. Test last cylinder at 56 days if 28-day cylinder is below specified strength.
 - 5. Flexural: Test one beam at 7 days and two beams at 28 days.
- E. Acceptance of concrete shall be in accordance with ACI 318/318R.
- F. Concrete with compressive strength less than specified, as evidenced by cylinder tested at 56 days, shall be additionally tested as follows:
 - 1. Less Than 500 pounds per square inch Low in Compression or Less Than 75 pounds per square inch Low in Flexure:
 - a. Penetration Resistance Test: ASTM C803.
 - b. Rebound Hammer Test: ASTM C805.
 - c. Perform tests within 24 hours of noncomplying strength tests.
 - 2. More Than 500 pounds per square inch Low in Compression or More Than 75 pounds per square inch Low in Flexure:
 - a. Concrete Coring: Take three standard cores from concrete representing original specimens.
 - b. Take and prepare cores in accordance with ASTM C42/C42M.
 - c. Test cores in accordance with ASTM C39/C39M.
 - d. Take cores within 24 hours of noncomplying strength test.

3.08 CLEANING

- A. Clean concrete splatter from exposed surfaces.
- B. Thoroughly broom and wash concrete surfaces before opening to traffic.

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3.09 PROTECTION OF CONCRETE

- A. Do not operate construction equipment or allow traffic on newly placed portland cement concrete until the following requirements are met:
 - 1. Joints have been filled as per Article Joints.
 - 2. Concrete has attained a compressive strength of at least 4,000 pounds per square inch.
- B. Protect new concrete from construction operations, mechanical disturbances, water flow, and soiling until open for traffic.
- C. Erect and maintain suitable barriers to protect concrete from traffic or other detrimental trespass until pavement is opened to traffic.
- D. Maintain watchmen after normal working hours for at least a 24-hour period to ensure barriers are not removed or destroyed, and that trespass and vandalism upon pavement does not occur.
- E. Wherever it is necessary that traffic, including Contractor's vehicles and equipment, be carried from one side of pavement to the other, construct suitable bridges over pavement, and maintain them in good condition as long as they may be required. Leaving gaps in pavement to facilitate movement of traffic will not be allowed, unless prior written permission is obtained from Engineer.
- F. Protect new concrete from dirt, asphalt, and other deleterious substances that may be tracked onto new pavement from construction activities.
- G. Pavement damaged by traffic or damaged from any other cause, prior to its official acceptance, shall be repaired or replaced to the satisfaction of Engineer.

END OF SECTION

SECTION 32 16 00
CONCRETE CURBS AND SIDEWALKS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): T 99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 inches) Drop.
2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ASTM International (ASTM):
 - a. C94, Standard Specification for Ready-Mixed Concrete.
 - b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

1.02 SUBMITTALS

A. Action Submittals:

1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

B. Informational Submittals:

1. Curing Compound: Manufacturer's Certificate of Compliance and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the 2025 Standard Specifications for Road, Bridge, and Municipal Construction, Washington State Department of Transportation.

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PART 2 PRODUCTS

2.01 EXPANSION JOINT FILLER

- A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.02 CONCRETE

- A. As specified in Section 03 30 00, Cast-in-Place Concrete.
- B. Maximum Aggregate Size: 1-1/2-inch.
- C. Slump: 2 inches to 4 inches.

2.03 CURING COMPOUND

- A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Perform Work in accordance with the referenced Standard Specification.

3.02 FORMWORK

- A. Lumber Materials:
 - 1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed curb and sidewalk.
 - 2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.
- B. Metals: Steel in new undamaged condition.
- C. Setting Forms:
 - 1. Construct forms to shape, lines, grades, and dimensions.
 - 2. Stake securely in place.

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D. Bracing:

1. Brace forms to prevent change of shape or movement resulting from placement.
2. Construct short-radius curved forms to exact radius.

E. Tolerances:

1. Do not vary tops of forms from gradeline more than 1/8-inch when checked with 10-foot straightedge.
2. Do not vary alignment of straight sections more than 1/8-inch in 10 feet.

3.03 PLACING CONCRETE

- A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.
- B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.
- C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.
- D. To compact, vibrate until concrete becomes uniformly plastic.

3.04 CURB CONSTRUCTION

- A. Construct ramps at pedestrian crossings.
- B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of curb and at connections to existing curbs. Install expansion joint filler at each joint.
- C. Curb Facing: Do not allow horizontal joints within 7 inches from top of curb.
- D. Contraction Joints:
 1. Maximum 15-foot intervals in curb.
 2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
 3. Insert steel sheet to full depth of curb.
 4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
 5. Finish top of curb with steel trowel and finish edges with steel edging tool.

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E. Front Face:

1. Remove front form and finish exposed surfaces when concrete has set sufficiently to support its own weight.
2. Finish formed face by rubbing with burlap sack or similar device to produce uniformly textured surface, free of form marks, honeycomb, and other defects.
3. Remove and replace defective concrete.
4. Apply curing compound to exposed surfaces of curb upon completion of finishing.
5. Continue curing for minimum of 5 days.

F. Backfill curb with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.

1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
2. Compact backfill firmly.

3.05 SIDEWALK CONSTRUCTION

A. Thickness:

1. 4 inches in walk areas.
2. 6 inches in driveway areas.

B. Connection to Existing Sidewalk:

1. Remove old concrete back to an existing contraction joint.
2. Clean the surface.
3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place in adjacent curb, where sidewalk ends at curb, and around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:

1. Provide transversely to walks at locations opposite contraction joints in curb.
2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
3. Construct straight and at right angles to surface of walk.

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E. Finish:

1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
2. Mark walks transversely at 5-foot intervals with jointing tool; finish edges with rounded steel edging tool.
3. Apply curing compound to exposed surfaces upon completion of finishing.
4. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

SECTION 32 91 13
SOIL PREPARATION

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C33/C33M, Standard Specification for Concrete Aggregates.
 - b. C602, Standard Specification for Agricultural Liming Materials.
 - c. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
 - d. D5268, Standard Specification for Topsoil Used for Landscaping Purposes.

1.02 SUBMITTALS

- A. Informational Submittals:
1. Certified Topsoil Analysis Reports:
 - a. Indicate quantities of materials necessary to bring onsite topsoil into compliance with textural/gradation requirements.
 - b. Indicate quantity of lime, quantity and analysis of fertilizer, and quantity and type of soil additive.

1.03 SEQUENCING AND SCHEDULING

- A. Perform Work specified in Section 31 10 00, Site Clearing, prior to performing Work specified under this section.

PART 2 PRODUCTS

2.01 TOPSOIL

- A. General: Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

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B. Composition:

1. In general accordance with ASTM D5268:
 - a. Gravel-Sized Fraction: Maximum 5 percent by weight retained on a No. 10 sieve.
 - b. Sand-Sized Fraction: Minimum 20 percent to 60 percent passing No. 10 sieve.
 - c. Silt and Clay-Sized Fraction: Minimum 35 percent to 70 percent.

C. Organic Matter:

1. Minimum 10 percent by dry weight in planting beds, as determined in accordance with ASTM D2974.
2. Minimum 5 percent by dry weight in turf areas, as determined in accordance with ASTM D2974.

D. pH: Range 6.0 to 8.0.

E. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

F. Source: Stockpile material onsite, in accordance with Section 31 10 00, Site Clearing. If quantity of topsoil required to achieve depths specified, exceeds stockpiled quantity, import material as needed. Imported topsoil must meet the requirements of this section.

2.02 SOURCE QUALITY CONTROL

- A. Topsoil Analysis/Testing: Performed by county or state soil testing service or approved certified independent testing laboratory.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

- A. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.
- B. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.
- C. Limit preparation to areas which will receive topsoil within 2 days after preparation.

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3.02 TOPSOIL PLACEMENT

- A. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.
- B. Mix soil amendments, lime, and other soil additives, identified in analysis reports with topsoil before placement or spread on topsoil surface and mix thoroughly into entire depth of topsoil before planting or seeding. Delay mixing of fertilizer if planting or seeding will not occur within 3 days.
- C. Place one-half of the total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer. Place remainder of topsoil to depth of 4 inches where seeding and planting are scheduled.
- D. Uniformly distribute to within 1/2-inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.
- E. Remove stones exceeding 1-1/2-inch diameter, roots, sticks, debris, and foreign matter during and after topsoil placement.
- F. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 GENERAL

1.01 DEFINITIONS

- A. Maintenance Period: Begin maintenance immediately after each area is planted (seed, sod, or sprig) and continue for a period of 8 weeks after all planting under this section is completed.
- B. Satisfactory Stand:
 - 1. Lawn and grass or section of lawn and grass of 10,000 square feet or larger that has:
 - a. No bare spots larger than 3 square feet.
 - b. Not more than 10 percent of total area with bare spots larger than 1-square foot.
 - c. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.02 SUBMITTALS

- A. Action Submittals: Product labels/data sheets.
- B. Informational Submittals:
 - 1. Seed:
 - a. Certification of Seed Analysis, Germination Rate, and Inoculation:
 - 1) Certify that each lot of seed has been tested by a testing laboratory certified in seed testing, within 6 months of date of delivery. Include with certification:
 - a) Name and address of laboratory.
 - b) Date of test.
 - c) Lot number for each seed specified.
 - d) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
 - 2) Mixtures: Proportions of each kind of seed.
 - 2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
 - 3. Certification of sod; include source and harvest date of sod, and sod seed mix.

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4. Certification of sprig type and name.
5. Description of required maintenance activities and activity frequency.

1.03 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.04 WEATHER RESTRICTIONS

- A. Perform Work under favorable weather and soil moisture conditions as determined by accepted local practice.

1.05 SEQUENCING AND SCHEDULING

- A. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.
- B. Complete Work under this section within 10 days following completion of soil preparation.
- C. Notify Engineer at least 3 days in advance of:
1. Each material delivery.
 2. Start of planting activity.
- D. Planting Season: March 15 through September 15.

1.06 MAINTENANCE SERVICE

A. Contractor:

1. Perform maintenance operations during maintenance period to include:
 - a. Watering: Keep surface moist.
 - b. Washouts: Repair by filling with topsoil, liming, fertilizing, seeding, and mulching.
 - c. Mulch: Replace wherever and whenever washed or blown away.
 - d. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.

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- e. Fence: Repair and maintain until satisfactory stand of grass is established.
- f. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
- g. Reseed/replant during next planting season if scheduled end of maintenance period falls after September 15.
- h. Reseed/replant entire area if satisfactory stand does not develop by July 1 of the following year.

PART 2 PRODUCTS

2.01 FERTILIZER

- A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose. Minimum percentage of plant food by weight.
- B. Mix:
 - 1. Type A: PAR EX 18-16-16 with slow release, BDU starter mix, as available from Wilbur-Ellis, Portland, OR, (503) 277-3525, “or-equal.”
 - 2. Type B: Woodburn Fertilizer 25-5-10 with 50 percent slow release, as available from Turf Care Products, (503) 620-0946, “or-equal.”

2.02 SEED

- A. Fresh, clean new-crop seed that complies with the tolerance for purity and germination established by Official Seed Analysts of North America.
- B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer’s instructions.
- C. Grass seed mix suitable for existing stormwater facility will be as described in Table 4.7 of the 2021 Clark County Stormwater Manual for wet soil conditions.

2.03 HYDROSEEDING MULCH

- A. Wood Cellulose Fiber Mulch:
 - 1. Specially processed wood fiber containing no growth or germination inhibiting factors.

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2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.
5. Silva-FiberPlus as manufactured by Weyerhaeuser.

2.04 NETTING

A. Jute:

1. Heavy-duty, twisted, weighing 1-pound per square yard.
2. Openings Between Strands: Approximately 2 inches.

B. Plastic:

1. Extruded Polypropylene: 20 mils.
2. Opening Between Strands: 1-inch by 2 inches.

C. Matting:

1. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.
2. Manufacturers and Products:
 - a. Akzo Industries, Ashville, NC; Curlex mat.
 - b. North American Green, Evansville, IN; S150 blanket.

2.05 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

1. Capable of hydrating in water, and to readily blend with other slurry materials.
2. Wood Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.
3. Manufacturers and Products:
 - a. Chevron Asphalt Co.; CSS 1.
 - b. Terra; Tack AR.
 - c. J Tack; Reclamare.

2.06 FENCE

- #### A.
- 2-inch by 2-inch posts 4 feet high, spaced 10 feet on center, and strung with single strand of No. 12 gauge wire marked with cloth strips at 3-foot intervals.

PART 3 EXECUTION

3.01 PREPARATION

- A. Grade areas to smooth, even surface with loose, uniformly fine texture.
 - 1. Roll and rake, remove ridges, fill depressions to meet finish grades.
 - 2. Limit such Work to areas to be planted within immediate future.
 - 3. Remove debris, and stones larger than 1-1/2-inch diameter, and other objects that may interfere with planting and maintenance operations.
- B. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry off before seeding. Do not create muddy soil.
- C. Restore prepared areas to specified condition if eroded or otherwise disturbed after preparation and before planting.

3.02 FERTILIZER

- A. Apply evenly over area in accordance with manufacturer's instructions. Mix into top 2 inches of topsoil, when applied by broad cast method.
- B. Application Rate: 23 pounds per 1,000 square feet (1,000 pounds per acre).

3.03 SEEDING

- A. Start within 2 days of preparation completion.
- B. Hydroseed slopes steeper than 3H:1V. Flatter slopes may be mechanically seeded.
- C. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipactor or roller.
 - 1. Sow seed at uniform rate of 7 pounds per 1,000 square feet.
 - 2. Use Brillion type seeder.
 - 3. Broadcasting will be allowed only in areas too small to use Brillion type seeder. Where seed is broadcast, increase seeding rate 20 percent.
 - 4. Roll with ring roller to cover seed, and water with fine spray.
- D. Hydroseeding:
 - 1. Application Rate: 42 pounds per 1,000 square feet.
 - 2. Apply on moist soil, only after free surface water has drained away.
 - 3. Prevent drift and displacement of mixture into other areas.

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- 4. Upon application, allow absorption and percolation of moisture into ground.
- 5. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning seed.
- E. Mulching: Apply uniform cover of wood fiber mulch at rate of 1,500 pounds per acre.
- F. Netting: Immediately after mulching, place over mulched areas with slopes steeper than 3:1, in accordance with manufacturer's instructions. Locate strips parallel to slope and completely cover seeded areas.
- G. Tackifier: Apply over mulched areas with slopes steeper than 4:1 at rate of 5 gallons per 1,000 square feet in accordance with the manufacturers recommended requirements.
- H. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 FIELD QUALITY CONTROL

- A. 8 weeks after seeding is complete and on written notice from Contractor, Engineer will, within 15 days of receipt, determine if a satisfactory stand has been established.
- B. If a satisfactory stand has not been established, Engineer will make another determination after written notice from Contractor following the next growing season.

3.05 PROTECTION

- A. Protect from pedestrian traffic by erecting temporary fence around each newly seeded area.

END OF SECTION

SECTION 33 05 01.01
WELDED STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.9, Factory-Made Wrought Buttwelding Fittings.
 - b. B36.10M, Welded and Seamless Wrought Steel Pipe.
 - c. BPVC SEC VIII, Division 1, Rules for Construction of Pressure Vessels.
 - d. BPVC SEC IX, Welding and Brazing Qualifications.
 2. American Society for Nondestructive Testing Inc. (ASNT):
SNT-TC-1A, Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing.
 3. American Water Works Association (AWWA):
 - a. C200, Steel Water Pipe - 6 Inches (150 mm) and Larger.
 - b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches (100 mm) and Larger - Shop Applied.
 - c. C206, Field Welding of Steel Water Pipe.
 - d. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 Inches Through 144 Inches (100 mm Through 3,600 mm).
 - e. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
 - f. C602, Cement-Mortar Lining of Water Pipelines in Place-4 Inches (100 mm) and Larger.
 - g. M11, Steel Pipe - A Guide for Design and Installation.
 4. American Welding Society (AWS):
 - a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - b. A3.0M/A3.0, Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
 - c. D1.1/D1.1M, Structural Welding Code - Steel.
 - d. QC 1, Standard for AWS Certification of Welding Inspectors.
 5. ASTM International (ASTM):
 - a. A20/A20M, Standard Specification for General Requirements for Steel Plates for Pressure Vessels.
 - b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

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- c. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
- d. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- e. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
- f. A435/A435M, Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates.
- g. A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
- h. A770/A770M, Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications.
- i. A1018/A1018M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
- j. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
- k. E1255, Standard Practice for Radioscopy.
- 6. International Organization for Standardization (ISO): 9001:2000, Quality Management Systems - Requirements.
- 7. Lloyd's Registry.
- 8. NSF International (NSF): 61, Drinking Water System Components-Health Effects.
- 9. Steel Pipe Fabricators Association (SFPA).

1.02 DEFINITIONS

- A. Fittings: Including, but not limited to fittings, closure pieces, bends, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to provide the Work, complete. Fittings shall include piping above ground or inside structures.
- B. Acronyms:
 - 1. CJP: Complete Joint Penetration.
 - 2. CWI: Certified Welding Inspector.
 - 3. MT: Magnetic Particle Testing.
 - 4. NDE: Nondestructive Examination.
 - 5. NDT: Nondestructive Testing.
 - 6. PJP: Partial Joint Penetration.
 - 7. PQR: Procedure Qualification Record.

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8. PT: Liquid Penetrant Testing.
9. RT: Radiographic Testing.
10. UT: Ultrasonic Testing.
11. VT: Visual Testing.
12. WPQ: Welder/Welding Operator Performance Qualification.
13. WPS: Welding Procedure Specification.

1.03 DESIGN REQUIREMENTS

A. Fittings:

1. Design reinforcement, unless otherwise shown.
2. Design in accordance with AWWA M11, AWWA C200, and AWWA C208 as modified herein, and this specification.

B. Pipe Layout:

1. Design in accordance with AWWA M11:
 - a. General:
 - 1) Base stationing and elevation convention as shown on the Drawings.
 - 2) Maximum Laying Lengths:
 - a) Not limited, unless specifically shown on the Drawings.
 - b) Select lengths to accommodate installation operation.
 - b. Include, as minimum:
 - 1) Specific number, location, and direction of each pipe, joint, and fitting. Number each pipe in installation sequence.
 - 2) Station and invert elevation at changes in grade or horizontal alignment.
 - 3) Location of mitered pipe sections, beveled ends for alignment conformance, butt straps, and deep bell lap joints for temperature stress control.
 - 4) Location of closures, cutoff sections for length adjustment, temporary access manways, vents, and weld lead outlets for construction convenience.
 - a) Provide for adjustment in pipe laying headings and to conform to indicated stationing.
 - b) Changes in location or number will require Engineer approval.
 - 5) Location of bulkheads, both those shown and as required, for hydrostatic testing of pipeline.

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C. Welding Procedure Specification (WPS):

1. Qualified by testing in accordance with ASME BPVC SEC IX for shop welds and AWS D1.1/D1.1M for field welds.
2. PQRs conducted on unlisted base metal (most coil products are unlisted base metals) to be production welded as required in the referenced welding Code shall be traceable to heat lots.
3. Written WPS required for welds, both shop and field.

D. Stulling (Strutting): Design for pipe and fittings such that over-deflection and damage is avoided during handling, storage, and installation, including backfill and compaction.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings showing pipe layout.
2. Material list and steel reinforcement schedules for materials specified.
3. Fabrication Information:
 - a. Pipe and fitting details for temporary and permanent facilities indicating:
 - 1) Cylinder thickness.
 - 2) Manufacturing tolerances.
 - 3) Maximum angular deflection limitations of field joints.
 - 4) Closure sections and cutoffs for field length adjustment.
 - 5) Bulkheads, including details for removal of test bulkheads and repair of lining.
 - 6) Weld lead outlets and plugs.
 - 7) Stulling size, spacing, and layout.
 - b. Welded joint details including:
 - 1) Butt joints.
 - 2) Miter-cut ends for alignment conformance.
 - 3) Lap joints.
 - 4) Special thermal control joints required for control of temperature stresses.
 - 5) Butt strap joints.
4. Welding Data (Shop and Field Welding):
 - a. Show on a weld map, complete information regarding base metal specification designation location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tail of welding symbol.
 - b. Distinguish between shop and field welds.

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- c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for all welds.
 - d. Welding and NDE symbols shall be in accordance with AWS A2.4.
 - e. Welding terms and definitions shall be in accordance with AWS A3.0M/A3.0.
 - f. Submit welding data together with Shop Drawings as a complete package.
 - 5. Product data for the following:
 - a. Welded Steel Pipe and Fittings:
 - 1) Material data.
 - 2) Chemical and physical test reports showing data consistent with specified requirements for each heat of steel proposed for use.
 - b. Rubber Gasket Joint:
 - 1) Details with dimensions and fabrication tolerances for both bell and spigot ends.
 - 2) Materials.
 - 3) Performance history or test data.
- B. Informational Submittals:
- 1. Certificates:
 - a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
 - b. Lining Materials: Certificate that lining system is currently approved for potable water contact in accordance with NSF 61 and satisfies current applicable governmental health and safety requirements for use in potable water.
 - 2. Pipe Manufacturer's written Quality Assurance/Control Plan.
 - 3. Statements of Qualification:
 - a. Pipe manufacturer.
 - b. Fittings fabricator.
 - c. Contractor's Shop Inspector.
 - d. Contractor's Field Inspector.
 - e. Certified Welding Inspector.
 - f. NDT Quality Control Personnel.

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4. Procedures:
 - a. Shop and field welding information; at a minimum include complete welding code paper trail with linkage to Shop Drawings.
 - b. Welder Qualifications and Welding Procedure Specifications in accordance with Section 05 05 23, Welding, and as specified below:
 - 1) Provide complete joint dimensions and details showing bevels, groove angles, root face, and root openings for all welds.
 - 2) Notch-tough welding procedures required. For shop and field welding, provide heat-input table on WPSs for welder guidance.
 - 3) Written WPS and PQR: Provide complete joint dimensions and details showing bevels, groove angles, root face, and root opening for all welds.
 - 4) Written NDT procedures.
 - 5) Current WPQ.
 - 6) Written description of proposed sequencing of events or special techniques such as:
 - a) Controlling pipe wall temperature stress during installation.
 - b) Minimizing distortion of steel.
 - c) Shop-Applied Cement-Mortar Lining: Include description of machine to be used and list of similar projects where machine was used. Identify pipe size and total footage.
 - d) Monitoring pipeline temperatures during installation.
 - c. Written weld repair procedures for the Work.
 - d. Field coating application and repair.
 - e. Field lining application and repair.
 - f. Written consumables control procedure for welding materials demonstrating: How consumables will be stored to comply with manufacturer's written instructions.
5. Reports:
 - a. Source Quality Control Test Reports:
 - 1) Hydrostatic testing.
 - 2) Nondestructive weld testing.
 - b. Field Quality Control Test Reports:
 - 1) Weld tests, including re-examination of repaired welds, on each weld joint for the following tests, as applicable:
 - a) Visual Testing (VT).
 - b) Radiographic Testing (RT).
 - c) Ultrasonic Testing (UT).

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- c. Cement-mortar lining compressive strength tests in accordance with AWWA C205.
- d. Cement-mortar coating absorption tests in accordance with AWWA C205.
- 6. Field Testing Plan:
 - a. Submit at least 15 days prior to testing and include following information at a minimum:
 - 1) Testing dates.
 - 2) Piping system and sections to be tested.
 - 3) Method of isolation.
 - 4) Method of conveying water from source to system being tested.
 - 5) Calculation of maximum allowable leakage for piping sections to be tested.
- 7. Design calculations prepared by a licensed professional engineer in the state of the Work for fittings, including opening reinforcement details of collars, wrappers, crotch plates; and harnessed joint assemblies.
- 8. Pipe manufacturer's design engineer's certification of training of Contractor's pipe installation crews.

1.05 QUALITY ASSURANCE

A. Qualifications:

- 1. Pipe Manufacturer:
 - a. Experienced in fabricating pipe of similar diameters, lengths, and wall thickness required for the Work.
 - b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
 - c. Demonstrate current production capability for volume of work required for Project.
 - d. Experience shall include successful fabrication to AWWA C200 standards of at least 100 linear feet of 48-inch diameter or larger pipe, with wall thickness of 0.375 inches or greater, within past 5-year period.
 - e. Experience shall be applicable to fabrication plant facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.

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2. Fittings Fabricator:
 - a. Experienced in fabricating fittings of similar diameters and wall thickness required for the Work.
 - b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
 - c. Demonstrate current production capability for volume of work required for this Project.
 - d. Experience shall include successful fabrication to AWWA C200 and AWWA C208 standards of at least 25 fittings of 48-inch or larger pipe, with wall thickness 0.375-inch or greater, within past 5-year period.
 - e. Experience shall be applicable to fabrication shop facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.
3. Welders and Welding Operators:
 - a. Shop Welders: In accordance with ASME BPVC SEC IX.
 - b. Field Welders: In accordance with AWS D1.1/D1.1M.
4. Contractor's Inspector for Shop and Field Welding:
 - a. In accordance with AWS QC 1, with knowledge of welding code for the Work.
 - b. After receiving CWI qualification, at least one Shop CWI and one Field CWI shall have 5 years' minimum professional experience related to welding inspection similar to the Work. Other CWIs may work under the supervision of 5-year CWI, provided they have 1 year of related professional experience after receiving CWI qualification.
5. NDT Quality Control Personnel:
 - a. In accordance with requirements of ASNT SNT-TC-1A, NDT Level II.
 - b. After receiving NDT qualification, at least one NDT person shall have 5 years minimum professional experience related to NDT inspection similar to the Work.

B. Contractor's Shop Inspector:

1. In accordance with AWWA C200.
2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.
 - b. Monitor conformance to approved WPS.
 - c. Monitor conformance to approved NDT procedure specifications.
 - d. Monitor conformance of WPQ.
 - e. Provide 100 percent visual inspection before, during, and after shop welding.

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- f. Coordinate NDT work and review test results.
- g. Maintain records and prepare report confirming results of inspection and testing.

C. Contractor's Field Certified Welding Inspector (CWI):

- 1. In accordance with AWWA C206 and AWS D1.1/D1.1M.
- 2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.
 - b. Monitor conformance to approved WPS.
 - c. Monitor conformance to approved NDT procedure specifications.
 - d. Monitor conformance of WPQ.
 - e. Provide 100 percent VT before, during, and after field welding.
 - f. Coordinate NDT work and review test results.
 - g. Maintain records and prepare report confirming results of inspection and testing.

D. Prefabrication Meeting:

- 1. Hold prior to fabrication of pipe and fittings between representatives of Owner, Contractor, Engineer, and pipe fabricator to review following:
 - a. Project scope.
 - b. Submittal requirements.
 - c. Testing.
 - d. Inspection responsibilities.
 - e. Shop welding requirements.
 - f. Field welding requirements.
 - g. Shop and field coating and lining requirements.
 - h. Production and delivery schedule.
 - i. Other issues pertinent to the Work.

E. Inspection of Coating and Lining Application: Qualified manufacturer's technical representative shall visit pipe coating and lining shop and Site at the beginning of application process to verify proper workmanship associated with coating and lining application and as may be required to resolve shop or field problems. Submit written report of visit to Engineer.

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1.06 DELIVERY, HANDLING, AND STORAGE

A. Pipe Marking:

1. Legibly mark installation sequence number on pipe and fittings in accordance with piping layout. Standard pipe sections do not need sequence number labeled provided wall thickness is clearly marked.
2. Fittings shall be marked at each end with notation "TOP FIELD CENTERLINE."
3. The word "TOP" shall be painted or marked on outside top spigot of each fitting.
4. Mark "TOP MATCH POINT" for compound bends per AWWA C208 so end rotations can be easily oriented in field.

B. Delivery:

1. Securely bulkhead or otherwise seal ends of pipe and fittings prior to loading at manufacturing site.
2. Pipe ends shall remain sealed until installation.
3. Damage to pipe and fittings, including linings and coatings, found upon delivery to Site shall be repaired to Engineer's satisfaction or removed from Site and replaced.

C. Storage:

1. Support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.
2. Support on sand or earth berms free of rock exceeding 3 inches in diameter.

1.07 SEQUENCING AND SCHEDULING

A. Notify Engineer in writing of the following:

1. Pipe Manufacturing: Not less than 14 days prior to starting.
2. Not less than 5 days prior to start of each of the following:
 - a. Welding.
 - b. Coating application.
 - c. Lining application.
 - d. Shop hydrostatic testing.

PART 2 PRODUCTS

2.01 GENERAL

A. Pipe Manufacturer:

1. Pipe and fabricated fittings shall be responsibility of one main Supplier.
2. If pipe and fabricated fittings are manufactured by separate Suppliers, one main Supplier shall be responsible for formally managing other Supplier. The one main Supplier is responsible for coordination and management of production of all pipe and fittings work of both Suppliers, including, but not limited to:
 - a. Qualifications.
 - b. Submittals.
 - c. Dimensional consistency between pipe and fittings.
 - d. Fabrication.
 - e. Quality assurance.
 - f. Quality control.
 - g. Reporting.
 - h. Shop lining.
 - i. Shop coating.
 - j. Shop testing.
 - k. Field services.
 - l. Delivery schedule.
 - m. Warranties or guarantees.

B. Pipe Size:

1. Unless shown otherwise for pipe over 30 inches in diameter, diameter shown shall be considered finished inside diameter after lining.
2. For pipe 30 inches in diameter and less, diameter shown shall be per ASME B36.10M.
 - a. Pipe size shall be nominal outside diameter for 14-inch diameter pipe and larger.
 - b. Pipe size shall be nominal inside diameter for 12-inch diameter pipe and smaller.

C. Steel pipe and fittings shall be manufactured, tested, inspected, and marked to comply with AWWA C200 and additional requirements of these Contract Documents.

D. In lieu of collar reinforcement, pipe or fittings with outlets may be fabricated in their entirety of steel plate having thickness equal to sum of pipe wall plus required reinforcement.

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2.02 PIPE BARREL

A. Steel:

1. Provide steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:
 - a. Specified Minimum Yield Strength: 36,000 pounds per square inch.
 - b. Specified Minimum Tensile Strength: 53,000 pounds per square inch.
 - c. Minimum Elongation in 2-inch Gauge Length: 21 percent.
 - d. Weld-ability:
 - 1) Maximum carbon equivalent of 0.45 as measured using AWC D1.1, Annex XI, Guideline on Alternative Methods for determining Preheat Formula:
$$CE = C + ((Mn + Si)/6) + (Cr + Mo + V)/5 + (Ni + Cu)/15$$
 - e. Steel Quality, as follows:
 - 1) Coils:
 - a) Continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing, and testing requirements of ASTM A1018/A1018M, SS Grade 36 Type 1.
 - b) Steel Chemistry:
 - (1) Carbon: 0.2 percent maximum.
 - (2) Manganese: 1.35 percent maximum.
 - (3) Aluminum: 0.02 percent minimum.
 - (4) Phosphorous: 0.025 percent maximum.
 - (5) Sulphur: 0.015 percent maximum.
 - 2) Plate:
 - a) Fully-killed, conforming to ASTM A20/A20M, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A516/A516M, Grade 70.
 - b) Steel Chemistry: Conform to ASTM A516/A516M, Grade 70. Steel plates that are 3/4-inch thick or greater shall be normalized.
 - 3) Maximum allowable thickness variation for plate, sheet, or coil shall be 0.010-inch less than ordered thickness.
 - 4) Do not provide pipe fabricated in accordance with ASTM A139 or ASTM API 5L, ASTM PLS 1.

2.03 FITTINGS

A. Fabrication:

1. Shop fabricate. No field fabrication will be allowed, unless approved by Engineer.
2. Fabricate from materials or straight pipe in conformance with specified requirements and dimensions of AWWA C208, unless otherwise indicated.

B. Wall Thickness:

1. General:
 - a. Refer to ASME B36.10M for definitions of wall thickness for standard weight pipe and nominal pipe size (NPS).
 - b. Reinforce to withstand either internal pressures, both circumferential and longitudinal, or external loading conditions, whichever is greater.
 - c. Minimum Plate Thickness: The greater of adjacent mainline pipe, thickness shown, thickness calculated as hereinafter specified, or as shown in Table 1.

Nominal Pipe Diameter (inches)	Piping in Structures
Over 24	3/8-inch

C. Bends, Unless Otherwise Indicated:

1. Minimum Radius: 1.5 times pipe diameter or as indicated on the Drawings.
2. Minimum Bend Wall Thickness: Greater of Table 1 above or as calculated for straight pipe under internal pressure multiplied by following bend stress intensities (tabulated below or calculated with the following bend stress intensity formula where “n” is the bend radius multiplier and SI equals bend stress intensity). For “n” greater than, or equal to 2.5 the stress intensity factor may be ignored as indicated in AWWA M11.

$$SI = \frac{2 \cdot n - \frac{1}{3}}{2 \cdot n - 1}$$

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Bend Radius Multiplier “n”	AWWA M11 Bend Stress Intensity “SI”
1.0	1.67
1.5	1.33
2.0	1.22

3. Maximum Miter Angle: 11-1/4 degrees on each section resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.
4. Bevels: Vary bevels on miters to provide a constant weld groove angle. For 11-1/4-degree miter, (22.5-degree miter weld) bevels must vary from 18.75 degrees on OD of bend to 41.25 degrees on ID of bend to provide a constant 60-degree groove angle for CJP welding.
5. Complete joint penetration (CJP) welds on miter welds.

D. Outlets:

1. Larger than 24 Inches: Fabricate from ASTM A106/A106M, Grade B, standard weight pipe.
2. Fabricate collar or wrapper reinforcement using same steel as specified for main pipe barrel.

E. Steel Butt-Weld Fittings:

1. Standard weight.
2. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
3. Coordinate difference in diameter convention between fittings and AWWA C200 and AWWA C208 pipe and fittings to provide complete piping system as shown.

2.04 JOINTS

A. Shop Welded:

1. Fabricate in accordance with AWWA C200 as modified herein.
2. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
3. Lengths of pipe shall not be shop-joined using lap joints.

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B. Preparation of Joints for Field Welding:

1. Butt Joint Welded:
 - a. Plain ends beveled as required by AWWA C200 and Contractor's field WPS.
 - b. Provide protection for factory beveled pipe ends so ends are not damaged during transport.

C. Miter-End Cuts:

1. Welded Butt Joints:
 - a. Maximum Total Allowable Angle: 2.5 degrees per pipe joint.
 - b. Minimum Pipe Wall Thickness: 3/8-inch.
 - c. Welded Butt joints shall be CJP.

2.05 FLANGES

- A. In accordance with AWWA C207.

2.06 RUBBER GASKET

A. General:

1. In accordance with AWWA C200.
2. Clearance between bell and spigot shall, when combined with gasket groove configuration and gasket itself, provide watertight joints under operating conditions.

2.07 STULLING (STRUTTING)

A. Materials:

1. Shop-Lined Pipe: Wood stulls and wedges.
2. Unlined Pipe: Steel or wood.

- B. Install stulling for pipe and fittings in accordance with approved submittal and as soon as practical after pipe is fabricated or, for shop-lined pipe, after lining has been applied.

- C. Install stulling in manner that will not harm lining.

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2.08 CEMENT-MORTAR COATING

A. General:

1. Notify Engineer at least 3 days prior to application of coating products.
2. Holdback of and coating from field-welded joints shall be as follows:
For butt weld and butt strap joints, 6 inches.
3. Unless otherwise indicated, coat exterior surfaces of pipe and fittings passing through structure walls from center of wall or from wall flange to end of underground portion.

B. Shop-Applied:

1. Cement-mortar coating shall conform to AWWA C205. Thickness shall conform to AWWA C205.
2. Steel wire or ribbon mesh reinforcement shall be in accordance with AWWA C205.
3. For cement-mortar coatings applied over dielectric coated pipe, ensure reinforcing metals in coating do not electrically contact pipe.
4. Coating system for field joints shall be cement mortar in accordance with AWWA C205. Mortar shall be retained with suitable water-impermeable bands or heavy-duty diapers of sufficient strength to hold fresh mortar and resist rodding.

2.09 CEMENT-MORTAR LINING

A. General:

1. Notify Engineer at least 3 days prior to application of lining products.
2. Holdback of lining from field-welded joints shall be as follows: For butt-weld and butt-strap joints, 6 inches.

B. Shop-Applied:

1. Applied centrifugally in conformance with AWWA C205. Thickness shall be in accordance with AWWA C205.
2. Lining machine type that has been used successfully for similar work and approved by Engineer.
3. Maintain pipe in round condition during lining operation and thereafter by suitable bracing or strutting.
4. Provide polyethylene or other suitable bulkhead on ends of pipe and on special openings to prevent drying out of lining. Bulkheads shall be substantial enough to remain intact during shipping and storage until pipe is installed.
5. Pipe shall be left bare where field joints occur.

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6. Ends of lining shall be left square and uniform. Feathered or uneven edges will not be permitted.

C. Field-Applied:

1. Materials conforming to AWWA C602.
2. Do not use pozzolanic material in mortar mix.
3. Admixtures shall contain no calcium chloride.
4. Wire mesh conforming to AWWA C205.

2.10 CATHODIC PROTECTION

- A. Provide as as specified in Section 40 27 00, Process Piping - General.

2.11 SOURCE QUALITY CONTROL

A. Shop Hydrostatic Pressure Test:

1. In accordance with AWWA C200 Section 5.2, except as follows:
 - a. General: Unless specified otherwise, testing of pipe and fitting shall be performed before lining and coating is applied.
 - b. Pipe: Maintain test pressure for minimum of 5 minutes.
 - c. Fittings: Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings fabricated from successfully tested straight pipe.

B. Shop Nondestructive Testing:

1. Welds: 100 percent visually examined by Contractor's Shop Inspector to criteria in ASME BPVC SEC VIII, Division 1.
2. CJP Butt Joint Groove Welds: Spot radiographically or radioscopically examine pipe in accordance with ASME BPVC SEC VIII, Division 1, Paragraph UW-52.
3. All Other CJP Groove Welds: Welds at tees and outlets shall be 100 percent ultrasonically examined in accordance with ASME BPVC SEC VIII, Division 1, Paragraph UW-53. Other types of groove welds that, in the opinion of the Engineer, cannot readily be radiographed, shall be 100 percent ultrasonically examined in accordance with Paragraph UW 53.
4. Fillet Welds: 100 percent examine using magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1, Appendix 6.
5. Air test collars and wrappers in accordance with AWWA C206.

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PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Joints and related work for field assembly of fittings shall conform to requirements for straight pipe, unless otherwise shown.
2. Inspect pipe and fittings before installation. Clean ends thoroughly, remove foreign matter and dirt from inside.
3. Make minor field adjustments by pulling standard joints.
 - a. Maximum Allowable Angle: 75 percent of manufacturer's recommended or angle which results from 3/4-inch pull out from normal joint closure, whichever is less.
 - b. Maximum Allowable Gap: 1/8-inch between bell and spigot at weld location.
4. Horizontal deflections or fabricated angles shall fall on alignment, as shown within tolerances below.
5. Vertical deflections shall fall on alignment, and pipe angle point locations shall match those indicated on the Drawings within tolerances below.
6. For field-welded joints, pipe 30 Inches in Diameter and Larger:
 - a. Ensure maximum penetration of spigot end into bell end is achieved through use of shop-welded tabs on inside circumference of bell end or by use of a paint stripe.
 - b. If welded metal tabs are used, remove tabs prior to welding inside of joint.
7. Stulling:
 - a. Maintain stulling in place until pipe is completely backfilled and compacted.
 - b. Reinstall stulls that were temporarily removed to facilitate interior welding prior to backfilling.
8. Pipeline Alignment Tolerances:
 - a. Plan: 3 inches.
 - b. Elevation: 3 inches.

3.02 WELDING

- A. Perform welding only in presence of Contractor's Field Inspector.
- B. Conform to AWS D1.1/D1.1M, AWWA C206, approved welding procedures, and referenced welding codes. In case of conflict AWS D1.1/D1.1M shall govern.

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- C. Preheat and Interpass temperature requirements for unlisted base metals shall be determined according to AWS D1.1/D1.1M, Annex XI Guideline on Alternative Methods for Determining Preheat.
- D. Rejectable weld defects shall be repaired or redone, and retested until sound weld metal has been deposited in accordance with appropriate welding codes.

3.03 REPAIR OF SHOP-APPLIED CEMENT-MORTAR COATINGS

- A. Exterior surfaces of steel pipe and fittings shall be inspected upon delivery to Site and just prior to backfilling trench.
- B. Repair of Cement Mortar Coating: Field repairs shall be made in accordance with AWWA C205.

3.04 COATING OF FIELD-WELDED JOINTS

- A. Using Cement Mortar: Applied to joints in accordance with AWWA C205.

3.05 FIELD-APPLIED CEMENT-MORTAR LINING

- A. General:
 - 1. Except for requirements specified in this section, lining of steel pipe shall be in accordance with AWWA C602.
 - 2. After joints are welded, air tested, and coated, and bedding and backfill have been placed, begin cleaning and lining operation with approval of Engineer. Access for cleaning and lining operations shall be at pipe access manholes or pipe ends. No cutting of openings in pipe will be allowed, unless approved in writing by Engineer.
 - 3. Internal Cleaning:
 - a. Prior to placing lining, pipe shall be thoroughly cleaned of foreign matter, including water.
 - b. Cleaning may be by hand or mechanical method that is approved by Engineer.
 - c. Waste materials and water from cleaning operations shall not be passed through sections of existing pipe or pipe that has already been lined.
 - d. No pipe shall be lined until inspected and approved by Engineer.
 - 4. Protection of Appurtenances:
 - a. Prevent mortar from being thrown into pipe openings in accordance with AWWA C602.
 - b. Outlet openings shall be trimmed, smoothed, and beveled.
 - c. Damaged or defective areas shall be repaired to satisfaction of Engineer.

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3.06 CEMENT-MORTAR LINING APPLICATION AT JOINTS

- A. Cement-Mortar Lining: For pipe with shop-applied cement-mortar lining, place lining at joints in accordance with AWWA C205.

3.07 CATHODIC PROTECTION

- A. Apply to pipe as specified in Section 40 27 00, Process Piping – General.

3.08 FIELD QUALITY CONTROL

- A. Field Welding:
 - 1. All welds, 100 percent inspection, shall be VT inspected by Contractor's Field Inspector and marked to indicate acceptance or rejection.
 - 2. Test butt-strap or double-welded lap joint welds by pressurizing connection between the two fillet welds in accordance with AWWA C206.
 - a. Apply air or other Engineer-approved gas into connection between the two fillet welds.
 - b. Paint welds with soap solution.
 - c. Mark leaks indicated by escaping gas bubbles.
 - d. Close threaded openings with flush pipe plugs or by welding them.
 - 3. CJP Welds:
 - a. Inspect 100 percent of butt joint welds with full circumference RT.
 - b. Inspect 10 percent of other groove welds with UT.
 - 4. Inspect 10 percent of lap joint welds with PT or MT.
 - 5. Weld Acceptance:
 - a. If, in the opinion of Engineer, inspections indicate inadequate quality of welds, percentage of welds inspected shall be increased.
 - b. Welds to be inspected, if less than 100 percent rate, shall be selected at random by Engineer.
 - c. VT: Perform VT per AWS D1.1/D1.1M Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - d. UT: Perform UT of CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.1.
 - e. RT: Perform RT of CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.

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- f. PT or MT:
 - 1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
 - 2) Acceptance shall be in accordance with VT standards specified above.
- g. Remove in manner that permits proper and complete repair by welding.
- h. Caulking or peening of defective welds is not permitted.
- i. Retest unsatisfactory welds.

B. Hydrostatic Testing:

- 1. Pipeline:
 - a. General:
 - 1) Notify Engineer in writing 5 days prior to testing. Perform testing in presence of Engineer.
 - 2) Test newly installed pipelines. Using water as test medium, pipes shall successfully pass a leakage test prior to acceptance.
 - 3) Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of make-up water under specified conditions.
 - 4) Isolate new pipelines that are connected to existing pipelines.
 - 5) Conduct field hydrostatic test on buried piping after trench has been completely backfilled. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
 - 6) Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
 - 7) Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
 - 8) Dispose of water used in testing in accordance with federal, state, and local requirements.
 - b. Procedure:
 - 1) Maximum filling velocity shall not exceed 0.25-foot per second, calculated based on the full area of pipe.
 - 2) Expel air from pipe system during filling. Expel air through air release valve or through corporation stop installed at high points and other strategic points.

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- 3) Test Pressure: 8 feet of head as measured at low point of pipeline.
 - 4) Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
 - 5) Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure.
 - 6) Determine actual make-up water by measuring quantity of water necessary to maintain specified test pressure for duration of test.
 - 7) If measured make-up water exceeds allowable or if leaks are visible, repair defective pipe section and repeat hydrostatic test.
- c. Allowable Make-up Water: For pipe with welded joints, no make-up water is allowed.

3.09 MANUFACTURER'S SERVICES

- A. Manufacturer's representative available at Site for installation assistance and training of pipe installation crews.
1. Coordinate pipe manufacturer's representative services.
 2. Pipe manufacturer's representative shall visit Site and instruct, guide, and provide procedures for pipe handling, laying, and jointing at start of pipe installation by each crew.

END OF SECTION

SECTION 33 05 01.10
HIGH-DENSITY POLYETHYLENE (HDPE) PRESSURE PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Class 25, Class 125, and Class 250.
 - b. B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
 - c. B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
 2. American Water Works Association (AWWA):
 - a. C906, Polyethylene (PE) Pressure Piping and Fittings, 4 inches through 65 inches for Waterworks.
 - b. Manual M55, PE Pipe - Design and Installation.
 3. ASTM International (ASTM):
 - a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A194/A194M, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - c. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 pounds per square inch Tensile Strength.
 - d. A536, Standard Specification for Ductile Iron Castings.
 - e. A563, Standard Specification for Carbon and Alloy Steel Nuts.
 - f. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
 - g. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 - h. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
 - i. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.

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- j. F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure.
- k. F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
- 4. Code of Federal Regulations (CFR): Title 49 Part 192.285, Plastic Pipe: Qualifying Persons to Make Joints.
- 5. NSF International (NSF): 61, Drinking Water System Components-Health Effects.
- 6. Plastics Pipe Institute (PPI):
 - a. Handbook of PE Pipe.
 - b. Technical Note 38, Bolt Torque for Polyethylene Flanged Joints.
 - c. TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Shop Drawings:
 - a. Catalog information confirming pipe, fittings, and other materials conform to requirements of this section.
 - b. Drawings of specific connection details.

B. Informational Submittals:

- 1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
- 2. Infrared temperature gun product data.
- 3. Certificates of qualification for persons to be fusing HDPE pipe.
- 4. Information on manufacturer and model of machine to be used for fusion of HDPE pipe.
- 5. Testing Plan:
 - a. Submit at least 15 days prior to testing and include the following as a minimum:
 - 1) Testing dates.
 - 2) Piping systems and section(s) to be tested.
 - 3) Method of isolation.
 - 4) Method of conveying water from source to system being tested.
- 6. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
- 7. Test report documentation.

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8. Installation Plan following the Plastic Pipe Institute, ASTM F2620, and manufacturer's recommendations. Plan shall include, but not be limited to the following major components:
 - a. Pipe and fitting storage.
 - b. Pipe and fitting handling equipment.
 - c. Proposed means to maintain required temperatures for fusing.
 - d. Proposed means to shield fusing area from wind, snow, blowing dust, and rain.
 - e. Proposed means to maintain uniform pipe wall temperature prior to fusing.
 - f. Temperature Control Plan: Plan shall include means to reduce temperature of pipe to limit stated in Part 3 of this specification.
9. Fusion parameters including recommended limits of criteria recorded by data logger.
10. Fusion report for each joint, including information listed under Article Field Quality Control. Submit joint reports within 24 hours after fusion.
11. Gasket manufacturer's table for recommended bolt torque and tightening pattern.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Pipe Manufacturer: Listed with Plastic Pipe Institute.
2. Experienced in fabricating pipe of similar diameters and wall thickness required for the Work.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipping: Do not cut, kink, or otherwise damage pipe during transportation.

B. Storage and Handling:

1. Pipe interiors are to be inspected and all debris removed prior to storage.
2. Limit stacking of pipe to a height that will not cause excessive deformation of bottom layers of pipes under anticipated temperature conditions.
3. Do not exceed the stacking heights stated in AWWA Manual M55.
4. Where necessary, because of ground conditions, store pipe on wooden sleepers, spaced suitably and of such widths as not to allow deformation of pipe at point of contact with sleeper or between supports.
5. Comply with the requirements of the approved Installation Plan.
6. Keep pipe shaded from direct sunlight prior to fusion and installation in trench.

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1.05 CONNECTIONS TO EXISTING PIPE

- A. Fusing to Existing Pipe: Comply with manufacturer's or distributor's recommendations based on Site conditions and PPI TR-33.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings:

1. Conform to requirements of AWWA C906.
2. In compliance with NSF 61.
3. Resin:
 - a. Non-Potable Water Transmission and Distribution Systems: Polyethylene resin shall meet or exceed requirements of ASTM D3350 for:
 - 1) PE 3608 material with cell classification of 345464C, or better. Pressure rating shall be based on hydrostatic design stress of 800 pounds per square inch at 73.4 degrees F.
 - 2) PE 4710 material manufactured from bimodal resin with cell classification of 445474C, or better. Pressure rating shall be based on hydrostatic design stress of 1,000 pounds per square inch at 73.4 degrees F.
4. Pressure Rating: 51 pounds per square inch and nominal DR of 26.
5. Outside Diameter Basis: IPS.
6. Pipe lengths, fittings, and flanged connections to be joined by thermal butt-fusion shall be of a compatible resin mix for the fusion process.
7. Fittings:
 - a. Polyethylene fittings shall have same or higher pressure rating as pipe.
 - b. Sizes 12 Inches and Smaller: Molded and manufactured to requirements of ASTM D3261.
 - c. Sizes Larger than 12 Inches: Thermal butt-fused fabricated.
 - d. Unless noted otherwise, provide fittings with a factory fused 4-foot-long spool on each end to facilitate onsite fusion.

B. Backup Rings:

1. Convolute for Flanged Connections:
 - a. ASTM A240/A240M, Type 316 stainless steel. ASTM A536, ductile iron.
 - b. Complete with one-piece, molded polyethylene flange adapters.
 - c. Flanged Connections: Same or greater pressure rating as pipe.

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2. Ductile Iron: Shop-primed with red oxide and shop-coated in accordance with requirements in Section 09 90 00, Painting and Coating. Shop-coated with two-part epoxy material in accordance with AWWA C550. Dry film thickness shall be 10 mils minimum.
 3. Gaskets: Material, size, and thickness shall be as recommended by gasket manufacturer and in accordance with PPI Technical Note 38. Gasket manufacturer shall provide a table with recommended bolt torque and tightening pattern.
- C. Joints: Thermal butt-fusion or electrofusion, except where connecting to unions, valves, and equipment with flanged or threaded connections that may require future disassembly. Use appropriate transition fitting or adapter for all joints that are not thermal butt-fused or electro-fused.
- D. Bolts, Nuts, and Washers:
1. Bolt Materials: Type 316 stainless steel, ASTM A193/A193M, Grade B8M hex-head, carbide solution treated and strained hardened.
 2. Bolt Fabrication: In accordance with ASME B18.2.1.
 3. Nut Materials: Type 316 stainless steel, ASTM A194/A194M, Grade 8 hex-head.
 4. Nut Fabrication: In accordance with ASME B18.2.2.
 5. Washers: Type 316 stainless steel. Same material as bolts in accordance with ASME B18.21.1.
 6. Thread Lubricant: Provide bolt manufacturer's recommended lubricant on bolt threads, nuts, nut face, and around bolt hole.
- E. Stiffening Inserts:
1. Stiffening inserts used to provide circumferential inside support of HDPE pipe ends shall be constructed of Type 316 stainless steel per ASTM A240.
 2. Thickness of metal stiffening inserts shall be as approved by pipe manufacturer and coupling manufacturer for the specific use.
- F. Wall Anchor:
1. Material: Same as HDPE pipe.
 2. Internal Diameter: Equal to adjacent pipe.
 3. Shear Strength: Equal to or greater than tensile strength of adjacent pipe.
 4. Fabrication: Butt fusion. Extrusion bead welding is not allowed.

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PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install polyethylene pipe in conformance with AWWA M55, PPI TR-33, ASTM F2620, and pipe manufacturer's recommendations.
2. Follow all requirements of approved Installation Plan where HDPE is to be installed in ambient temperatures less than 50 degrees F, in hot conditions or in windy conditions.
3. Protect and install pipe in accordance with the Temperature Control Plan when contraction of pipe length may cause damage to or pull out from structures.

B. Joining: Butt-fuse pipes and fittings in accordance with pipe manufacturer's recommendations. Depending on Site conditions, perform butt-fusion joining in or outside of excavated trench.

1. Remove and extract internal fusion bead from pipe.
 - a. Verify complete internal fusion bead removal was performed. Accomplish by examination of extracted internal fusion bead or by means of closed-circuit television (CCTV) examination.
 - b. Extracted Internal Fusion Bead:
 - 1) Appearance shall have same double roll back semblance as external fusion bead.
 - 2) Possess smooth root cut or pipe smoothness and shall be verified by means of closed-circuit television (CCTV) examination.
 - c. Removal of internal bead may include pipe wall mass. However, wall mass that is removed shall not exceed 1/10th of pipe wall thickness.
2. If HDPE pipe surface temperature is above 90 degrees F as measured with infrared temperature gun, allow pipe to cool prior to making any connections to flanges, existing pipeline systems, or structures.
3. Connect HDPE pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems with flanged connections as follows:
 - a. Polyethylene flange adapter, thermally butt-fused to end of pipe. Flange "stub ends" are not allowed.
 - b. Convolute backing flange, as specified.
 - c. Bolt and nut of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard.

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- d. Follow requirements of PPI Technical Note 38 including mandatory 4-hour bolt re-torquing.
- 4. Special Precautions at Flanges: Support polyethylene pipe connected to heavy fittings, manholes, and rigid structures in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

3.02 FIELD QUALITY CONTROL

A. Joint Butt Fusion:

- 1. Measure and log each joint fusion by an electronic monitoring device (data logger) affixed to fusion machine. Data to be logged shall include the following and shall be capable of being retrieved electronically:
 - a. Pipe size, dimensions, and wall thickness.
 - b. Machine model and size.
 - c. Operator identification.
 - d. Job identification number.
 - e. Weld number.
 - f. Fusion, heating, and drag pressure settings.
 - g. Heater plate temperature.
 - h. Time stamp showing when weld was performed.
 - i. Heating and curing time of weld.
 - j. Curing temperature readings and time stamps of readings.
 - k. Error messages and warnings for out of range temperature or pressure settings.
- 2. In addition to logged items above, the following shall be logged or annotated on report:
 - a. Location of joint being fused by pipeline station or by reference to pipe Shop Drawing.
 - b. Ambient temperature and humidity.
 - c. If internal bead was removed.
 - d. Environmental actions taken (such as, use of tarps, enclosures, and blankets).
 - e. Type of HDPE and manufacturer.

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B. Joint Weld Inspection:

1. Visually examine each joint in accordance with the guidelines in ASTM F2620. Remove and replace any joints not meeting the standard.
2. Mechanical Joint Testing:
 - a. Pipe Wall Thickness Greater than 1-Inch: Test joints in accordance with the guided side bend testing in accordance with ASME BPVC, Section IX, Article XXI-XXIV.
 - b. Specimens: Cut pipe 12 inches on each side of field made joint. Rejoin ends and proceed with Work.
 - c. Test Frequency:
 - 1) First two joints selected at random by Engineer.
 - 2) Each Additional one joint selected at random by Engineer.
 - 3) Each Test Failure: Two additional joints selected at random by Engineer.

C. Pipeline Hydrostatic Test: Perform in accordance with Section 40 80 01, Process Piping Leakage Testing.

3.03 MANUFACTURER'S SERVICES

- A. Provide pipe manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for assistance during pipe joining operations and pipe installation.

END OF SECTION

**SECTION 33 41 01
STORM DRAIN PIPING**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:
1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M36M, Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
 - b. M190M, Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.
 - c. M196M, Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
 2. American Water Works Association (AWWA):
 - a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3 inches Through 48 inches (75 mm Through 1200 mm) for Water and Other Liquids.
 - d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water.
 3. ASTM International (ASTM):
 - a. A746, Standard Specification for Ductile Iron Gravity Sewer Pipe.
 - b. C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
 - c. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
 - d. C150, Standard Specification for Portland Cement.
 - e. C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete.
 - f. C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
 - g. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.

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- h. C443, Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
- i. C497, Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
- j. C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
- k. C595, Standard Specification for Blended Hydraulic Cements.
- l. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
- m. C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.
- n. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
- o. C1012, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
- p. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
- q. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- r. D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
- s. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- t. D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
- u. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- v. F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
- w. F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
- x. F894, Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

1.02 SUBMITTALS

A. Informational Submittals: Manufacturer's Certification of Compliance.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

- A. As specified in the Data Sheet following “End of Section.”

PART 3 EXECUTION

3.01 INSTALLATION OF PIPE, FITTINGS, AND APPURTENANCES

- A. General:

1. Pipe laying shall proceed upgrade with spigot ends pointing in direction of flow.
2. Excavate bell holes at each joint to permit correct assembly and inspection of entire joint.
3. Pipe invert may deviate from line or grade up to 1/2-inch for line and 1/4-inch for grade, provided that finished pipe line will present a uniform bore, and such variation does not result in a level or reverse sloping invert, or less than minimum slope shown.
4. Pipe bedding shall form continuous and uniform bearing and support for pipe barrel between joints. Pipe shall not rest directly on bell or pipe joint.
5. Prevent entry of foreign material into gasketed joints.
6. Plug or close off pipes that are stubbed off for manhole, concrete structure, or for connection by others, with temporary watertight plugs.

- B. Concrete Closure Collars: Only use concrete closure collars where shown or authorized by Engineer.

3.02 PRESSURE TESTING

- A. As specified in Section 40 80 01, Process Piping Leakage Testing.

3.03 REPAIR AND RETESTING

- A. Sections of pipe not meeting the pressure test requirements shall be replaced or have individual joints tested and sealed.
- B. Following repairs, sections shall be retested as specified.

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3.04 SEWER CLEANING

- A. Prior to final acceptance and final manhole-to-manhole inspection of the sewer system by Engineer, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the sewer system at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.
- B. Upon Engineer's final manhole-to-manhole inspection of the sewer system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

3.05 SUPPLEMENT

- A. Data Sheet:

<u>Number</u>	<u>Title</u>
Section 33 41 01.03	Polyvinyl Chloride (PVC)

END OF SECTION

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SECTION 33 41 01.03 POLYVINYL CHLORIDE (PVC)	
Item	Description
Pipe: 15-inch diameter and under	ASTM D3034: Standard dimension ratio less than 35, except that the cell classification shall be 12454-B or 12454-C as defined in ASTM D1784.
Pipe: 18-through 24-inch diameter	ASTM F679: Standard dimension ratio less than 35, except that the cell classification shall be 12454-C as defined in ASTM D1784.
Joints	ASTM D3212 rubber gasketed.
Gaskets	ASTM F477. Lubricants: As approved by manufacturer.
Fittings	PVC, Gasketed: Provide plug when service piping is not required.
Plugs	Removable: Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.
Source Quality Control Testing	In accordance with specified ASTM.

END OF SECTION

SECTION 33 44 13.13
CATCH BASINS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Welding Society (AWS): Code for Welding in Building Construction.
 2. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A48/A48M, Standard Specification for Gray Iron Castings.
 - c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - e. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
 - f. C478, Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.

1.02 SUBMITTALS

- A. Action Submittals: Catch basin product data sheet and dimensional drawings for all products.

1.03 PART 2 PRODUCTS

1.04 CONCRETE

- A. Type: Ready-mixed, conforming to ASTM C94/C94M, Alternate 2.
- B. Compressive Field Strength: Not less than 2,500 pounds per square inch at 28 days.
- C. Maximum Size of Aggregate: 1-1/2-inch.
- D. Slump: Between 2 inches and 4 inches.
- E. Assumed Field Strength: 85 percent of strength of laboratory-cured cylinders.

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1.05 FORMS

- A. Exposed Surfaces: Plywood.
- B. Other Surfaces: Steel, matched boards, plywood, or other acceptable material.
 - 1. Trench walls, large rock, and earth are not acceptable form material.
- C. Form vertical surfaces.
- D. Provide fillets on re-entrant angles.

1.06 REINFORCING STEEL

- A. Conform to ASTM A615/A615M, Grade 60, deformed bars.

1.07 PRECAST UNITS

- A. At the option of Contractor, approved precast units may be substituted for cast-in-place units.
- B. Conform to ASTM C478 Submit details of proposed units to Engineer for review.
- C. Concrete Risers for Extensions: 6 inches high maximum and of same quality as sections.
 - 1. Confirm acceptability of risers with Engineer before installation.

1.08 MORTAR

- A. Standard premixed mortar conforming to ASTM C387/C387M, Type S, or proportion one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.
- B. Admixtures may be used if not exceeding the following percentages of weight of cement:
 - 1. Hydrated Lime: 10 percent.
 - 2. Diatomaceous Earth or Other Inert Materials: 5 percent.
- C. Consistency of Mortar: As required to readily adhere to concrete.

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1.09 FRAMES AND GRATES

- A. Frames and Grates for Catch Basins and Storm Drain Inlets: As specified in Clark County Standard Detail D4.2 and D4.4. Steel conforming to ASTM A36/A36M. Cast iron conforming to ASTM A48/A48M, Class 30.

PART 3 EXECUTION

2.01 EXCAVATION AND BACKFILL

- A. Excavate as required to accomplish construction. Backfill as specified for adjoining pipe trench.

2.02 CONSTRUCTION OF CATCH BASINS AND INLETS

- A. Construct inlets and catch basins at locations shown and in accordance with the Drawings. Construct tight and well-braced forms to dimensions and elevations required. Chamfer form corners.
- B. Prior to placing concrete, remove water and debris from forms. Moisten forms just prior to placing concrete. Handle concrete from transporting vehicle to forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with mechanical vibrator. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.
- C. Screed top surface of exposed slabs and walls. When initial water has been absorbed, float surfaces with wood float and lightly trowel with steel trowel to smooth finish free from marks or irregularities. Finish exposed edges with steel edging tool. Remove forms and patch defects in concrete with mortar mixed in same proportions as original concrete mix.
- D. Use a membrane-forming curing compound to prevent loss of moisture for 7 days. Apply curing compound immediately after removal of forms or finishing of slabs. Protect concrete from damage during curing period.

2.03 PLACING PRECAST UNITS

- A. If material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean, pit-run material. Set units to grade at locations shown.

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2.04 EXTENSIONS

- A. Install watertight extensions as shown. Lay risers in mortar with sides plumb and tops to grade. Seal joints with mortar, with interior and exterior troweled smooth. Prevent mortar from drying out and cure by applying a curing compound.

2.05 INSTALLATION OF FRAMES AND GRATES

- A. Set frames and grates at elevations indicated or as determined in field and in conformance with the Drawings.
- B. Frames may be cast in, or set in mortar.

2.06 CLEANING

- A. Upon completion, clean structure of silt, debris, and foreign matter.

END OF SECTION

**SECTION 35 20 16.25
FABRICATED SLIDE GATES AND STOP LOGS**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Water Works Association (AWWA):
 - a. C561, Fabricated Stainless Steel Slide Gates.
 - b. C562, Fabricated Aluminum Slide Gates.
 2. ASTM International (ASTM):
 - a. A193/A193M, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
 - c. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - d. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - e. B209, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate.
 - f. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
 3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 4. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 DEFINITIONS

- A. Self-Contained: The arrangement of gate operator, supported by gate frame, such that operating thrust loads are not applied external to the assembly.
- B. Slenderness Ratio: The ratio of the maximum unsupported stem length to the stem cross-section radius of gyration.
- C. Submersible: The ability to exclude water when submerged under a 20-foot head of fresh water for 24 hours and still maintain electrical integrity.

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1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Make, model, weight, and horsepower of each equipment assembly.
 - b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Detailed structural, mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment associated therewith.
 - d. Gate operator and stem calculations for each gate and service condition.
 - e. Structural calculations for gate frames requiring a splice. Refer to Gate Schedule.
 - f. Gate opening and closing thrust forces that will be transmitted to the support structure with operator at extreme positions and load.
 - g. External utility requirements such as air, water, power, drain, etc., for each component.
 - h. Functional description of internal and external instrumentation and controls to be supplied including list of parameters monitored, controlled, or alarmed.
 - i. Power and control wiring diagrams, including terminals and numbers.
 - j. Performance Test Procedures.
 - k. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's written/printed installation instructions.
5. Routine maintenance requirements prior to plant startup.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

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1.04 SYSTEM DESCRIPTION

- A. Coordinate such that electric motor operators are fully assembled and tested, including motor, at the factory.

1.05 EXTRA MATERIALS

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

Item	Quantity
Stem collars for all gate stems.	One of each different size.
Bronze lift nuts.	One of each different size.
Indicator lights.	One dozen.
Wearing parts (seals, bearings) recommended by manufacturer to be changed during first year of service or that may reasonably be expected to need replacing during the first year of service.	One complete set for each gate installed.
Initial lubricant, as recommended by manufacturer, in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by the Owner.	One quantity for each gate installed.
One year's supply of lubricant of type and grade recommended by manufacturer.	One quantity for each gate installed.
Special tools required to maintain or dismantle.	One complete set.

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 SUPPLEMENTS

- A. See supplements to this section for additional product information.

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2.02 MATERIALS

- A. Aluminum Plate and Shapes (Stop Logs Only): ASTM B209 and ASTM B308/B308M, Alloy 6061-T6.
- B. Stainless Steel:
 - 1. Plate, Sheet, and Strip: ASTM A240/A240M.
 - a. Slide Gates: Type 316/316L.
 - 2. Bars and Shapes: ASTM A276.
 - a. Slide Gates: Type 316/316L.

2.03 PERFORMANCE REQUIREMENTS

- A. Leakage shall not exceed 0.05 gallon per minute per foot of gate periphery under either seating or unseating head conditions.

2.04 SLIDE GATES

- A. Unless otherwise specified, conform to AWWA C561.
- B. Rising stem type, with assembly styles designated as follows:
 - 1. Style B: Upward acting type for mounting in channels with concrete embedded frame and invert.
- C. Guide Frames:
 - 1. Stainless steel of one-piece design, unless indicated otherwise in Gate Schedule, with gussets provided to accommodate unseating head. Sandwich type and two-piece guide designs are not acceptable. Portion of wall-mounted frame, where anchors penetrate, shall have a minimum thickness of 1/2-inch.
 - 2. Vertical Guides: Design for maximum rigidity and extend in one continuous piece from the gate invert to form posts for support of gate operators of self-contained gates. When guides extended above the operating floor, they shall be sufficiently strong so that no further reinforcements are required.
 - a. Weight: Not less than 6.5 pounds per linear foot for channel-mounted gates.
 - b. Incorporate a replaceable, self-adjusting, UV-stabilized UHMW polyethylene seal with nitrile compression cord. Seal shall be mechanically fastened in the guide slot on both the upstream to downstream sides of the disc. No wedges, pressure pads or similar wedging devices are allowed.

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- c. “J-bulb,” “P-seals,” “d-seals” or similar rubber seals are not acceptable.
 - 3. Frame Invert: For flush bottom gate, furnish an EPDM insert to function as a seating surface for the gate disc.
 - a. Weight: Not less than 6.5 pounds per linear foot for channel-mounted inverts.
 - 4. Join vertical guide frames and invert with factory welded corners.
 - 5. Size guided slot to provide a minimum disc engagement of 1-inch on each side.
- D. Disc:
 - 1. Disc Plate (Sliding Member): One-piece stainless steel plate. Reinforce as required so that the disc will not deflect more than $1/720$ of the gate span, or $1/16$ -inch, whichever is less, when the upstream liquid depth (seating head side) is as shown on the schedule and the downstream liquid depth is less than $1/2$ inch.
 - 2. Reinforce gate disc with one-piece stainless steel angles or channels welded to the disc plate. Bolted reinforcements will not be permitted.
 - 3. Portion of slide that engages the frame shall have a minimum thickness of $1/2$ inch.
 - 4. On nonrising stem gates, slide shall be arranged to allow travel of the stem along length of slide.
- E. Operator Support Yoke:
 - 1. For self-contained gate operators, attached to the vertical extensions of the guide frames.
 - 2. Constructed from at least two stainless steel angles, or two other suitable shapes, and bolt in place to provide a rigid assembly.
 - 3. Maximum Deflection: Not to exceed $1/16$ inch under full operator applied loading.
- F. Stems:
 - 1. 1-1/2-inch minimum diameter, ASTM A276, Type 316L stainless steel.
 - 2. Threads: Acme type with RMS surface roughness of 16 microinches or less on the flanks. Extend threaded portion of stem 2 inches above operator when gate is in CLOSED position.
 - 3. Ratio of the unsupported stem length to the radius of gyration, both in inches, shall not exceed 200.
 - 4. Stems to withstand in compression, without damage, the thrust equal to at least 2-1/2 times the rated output of the hoisting mechanism, with a 40-pound effort applied to the handwheel or crank.

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5. Design electric motor-driven floor stands to withstand at least 1.25 times the output thrust of the motor in the stalled condition.
 6. Adjustable stop collar for the CLOSED position.
 7. Connect the stems to the disc plate with a yoke, bolted to the stem and welded to the disc.
 8. For nonrising stem gates, lift nut or threaded insert in disc yoke shall be field-replaceable.
 9. Slide gates having a width greater than twice the height shall have dual stems. For downward opening weir type gates, locate stems near outside edges of gate.
- G. Guides: Type 316 stainless steel stem guides, mounted on fabricated wall brackets or mounted directly to frame and spaced so that L/r ratio of stem does not exceed 200. Guides mounted to wall shall be adjustable in two directions.
- H. Stem Covers:
1. Transparent plastic, vented pipe stem cover and cap.
 2. Provide with OPEN/CLOSED designators with 1-inch graduations on clear mylar pressure sensitive, adhesive tape, suitable for outdoor application.
- I. Manufacturers:
1. Whipps, Inc.
 2. Rodney Hunt Co.
 3. H. Fontaine, Ltd.
 4. Hydro Gate Corp.

2.05 GATE OPERATORS

- A. General:
1. Components: Withstand a minimum of 250 percent of design torque or thrust at extreme operator positions without damage.
 2. Mount at walkway level, 36 inches above floor, unless otherwise indicated or required.
 3. Gear train and gate stem sections shall produce a self-locking drive train.
 4. Lift Nuts: Internally threaded with cut or cold-rolled Acme threads corresponding to stem threading.
 5. Roller Bearings: Ball-thrust or tapered above and below lift nut to support both opening and closing thrusts.
 - a. Grease lubrication fittings for bearings.
 - b. Input pinions with needle or ball bearings.

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6. Lubrication: Furnish rising stem gates with an insert lubricator flange in lift, with grease fitting for greasing stem threads below stem nut.
- B. Type 4, Electric Motor Operators:
1. 28-inch-high steel pedestal or direct yoke-mounted, totally enclosed weatherproof electric drive unit, and a totally enclosed gear box that operates a two-piece, bronze stem nut, which lifts the gate stem.
 2. Gears: Heat treated alloy steel, supported throughout by antifriction ball or roller bearings and grease lubricated.
 3. Automatic double-acting geared limit switches and double-acting torque switches. See exceptions in Paragraph 2.05.B.7.
 - a. Gear directly to the operating gear train and shall be “in step” at all times, whether in motor or manual operation.
 - b. Wire geared limit switches internally to stop the motor at the fully OPEN and fully CLOSED positions.
 - c. Wire torque switches internally so that, in the event of a mechanical overload in either direction, the motor will be stopped.
 4. Equip with side mounted handwheel for manual operation.
 - a. Include an automatic clutch to positively disengage the handwheel at any time the drive motor control is energized.
 - b. Design handwheel operator so that failure of the motorized gearing will not prevent hand operation of the gate.
 5. Drive Unit:
 - a. TENV, 480-volt, three-phase electric motor as specified in Section 26 20 00, Low-Voltage AC Induction Motors, with integral OPEN/STOP/CLOSE weatherproof pushbuttons or lockable hand switch, reversing controller, 480/120-volt control power transformer, space heaters in the limit switches and in the control compartments, mechanical dial type position indicator, and transparent plastic pipe stem cover and cap, unless otherwise specifically noted on the Drawings. See exceptions in Paragraph 2.05.B.7.
 - b. Furnish motor enclosure with drainage and breathing holes. See exceptions in Paragraph 2.05.B.7.
 - c. Self-locking, with approximately 12 inches per minute gate travel speed, and a rated running torque equal to 20 percent of the motor starting torque at a rated running time of 15 minutes, without exceeding the allowable NEMA temperature rise for the insulation class used.
 6. Operation: Drive the gate to its fully OPEN or CLOSED position when the OPEN or CLOSED pushbutton or lockable hand switch is engaged momentarily. Motor shall stop in mid-travel when the STOP button or hand switch is engaged.

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7. For permanent magnet type motors, with equal start and run torque, no torque switches or thermal overload protection shall be required. Such motors must be torque self-limiting. No space heaters, drainage or breathing holes required. Exceptions to Paragraphs 2.05 B.3.c, and 2.05 B.5.a and b shall apply
8. Controls:
 - a. Furnish the following in accordance with operator control styles listed below and specified in Supplement Slide Gate Schedule:

Feature	Description
A	Local OPEN/STOP/CLOSE pushbutton station
B	End position limit switches; OPEN and CLOSED position switches shall be normally open contacts that close at the end position; contacts shall be dry and rated for 5 amps, 120V ac.
D	LOCAL/REMOTE weatherproof selector switch and provisions for remote OPEN/STOP/CLOSE operation; remote commands will be by way of a four-wire circuit, as shown; motor operator shall impress the voltage required to read these contacts and shall go to the commanded position or stop when in the REMOTE mode. Provide auxiliary contact which closes when LOCAL/REMOTE switch is in REMOTE position.

- b. Operator Control Style:
 - 1) Style 3: Includes control features A, B, and D.
9. Manufacturers:
 - a. Rotork Controls.
 - b. Harold Beck & Sons, Inc.
 - c. Flowserve Limitorque.

C. Identification Tagging Requirements:

1. For each gate operator, furnish 16-gauge, Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high engraved block type black enamel filled gate tag number shown in the schedule.
2. Attach the tags to the operator by soldered split key rings to that ring and tag cannot be removed. Use block type numbers and letters with 1/4-inch minimum high numbers and letters stamped on and filled with black enamel.

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2.06 ALUMINUM STOP LOGS

A. Stop Log Service Conditions:

1. Guide Frame Invert and Side Mounting: Refer to Supplement Stop Log Schedule and installation details on the Drawings. Installation to have concrete blockout in channel wall and floor and packed with nonshrink grout or surface-mounted stop log frame installed per manufacturer's directions.
2. See supplement at end of this section for locations and specific service conditions.

B. Stop Logs:

1. Stop logs shall be 2 feet high, one-piece aluminum extrusions or plate, reinforced as required to limit deflection to not more than 1/360 of span or 1/4-inch, whichever is less, at the specified design head.
2. Reinforced stop log thickness shall not exceed 7 inches. Each log shall have lifting bars or pins to facilitate lifting and removal with lifting devices.
3. Neoprene bulb or lip seals for seating surface of stop log against frame, invert, and between stop logs. Secure seals with Type 316 stainless steel bearing strips and machine screws with locking type nuts.
4. Interchangeable, so they can operate in any order of placement.
5. Stop Log Dimensions: Lengths of stop logs, listed in the following schedule, are given as nominal channel width at the stop log. Verify actual stop log lengths required before submitting the Shop Drawings.

C. Guide Frames:

1. Guide frames and invert shall be Type 316L stainless steel.
2. Vertical guides designed for maximum rigidity and shall extend in one continuous piece from flush gate invert to channel wall top (less the thickness of the covers and frames) so top of vertical guide is 1/2-inch below cover angle frame support horizontal leg, in the field installed position. Coordinate dimensions from channel wall and top with cover manufacturer.
3. Provide with grouting anchor flange as one leg of a structural angle. Vertical guide total width, up and downstream of gate shall be a minimum of 7 inches to a maximum of 10 inches, including grouting flange.
4. Vertical guide frames and inverts shall be joined with factory-welded corners. Unvented invert length shall not exceed 24 inches.

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5. Sized to provide a minimum disc engagement of 1-1/2 inches of each side.
- D. Lifting Devices: One lifting device complete with lifter body, hooks, lifting cables and extension arms, complete, shall be provided for each different gate span to install and remove stop logs.
- E. Storage Racks:
 1. Provide stop log storage racks of same material as guide frames, sized to store total number of specified stop logs for each facility indicated on the Stop Log Schedule. Coordinate location of storage rack with Owner out of footprint of construction.
 2. Stop log storage racks shall have the Ultra High Molecular Weight (UHMW) bearing pads and enclosed channels for transport with a forklift or pallet jack.
 3. Final quantity, configuration, and locations of racks shall be approved by Design Engineer.
- F. Tagging Requirements: Each stop log shall include a rectangular, riveted, or welded aluminum tag with stop log span and depth shown. Tag shall also state "water side" and be affixed to water side of stop log.
- G. Manufacturers:
 1. Whipps, Inc.
 2. Rodney Hunt Inc.
 3. RW Gate Company.
 4. Hydro Gate Corp.
 5. "Or-equal."

2.07 APPURTENANCES

- A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.
- B. Anchor Bolts: ASTM A193/A193M, Type 316 stainless steel sized by equipment manufacturer at least 1/2-inch in diameter, or as shown, and as specified in Section 05 50 00, Metal Fabrications.
- C. Staff Gauges: For stainless steel, downward acting weir gates. Graduated in 1/4 inches and marked every inch and foot.
 1. Manufacturer and Product: Stevens Water Monitoring Equipment; Porcelain Enameled Style C.

2.08 SHOP/FACTORY FINISHING

- A. Mechanically descale and passivate all weld burn and weld slag in accordance with ASTM A380 to provide uniform finish.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with the manufacturer's written instructions.
- B. Disassemble factory assembled gate components before installation.
- C. Field mount operators after installing gates.
- D. Brace thimbles internally during concrete placement.
- E. Accurately place anchor bolts using templates furnished by the manufacturer and as specified in Section 05 50 00, Metal Fabrications.
- F. Lubricate stems before operating.

3.02 FIELD QUALITY CONTROL

- A. Functional Tests: Conduct on each slide gate.
- B. Performance Test:
 - 1. Conduct on each slide gate.
 - 2. Perform under actual or approved simulated operating conditions.
 - 3. Test for a continuous 3-hour period without malfunction.
 - 4. Adjust, realign, or modify units and retest if necessary.

3.03 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative:
 - 1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
 - a. 1 person-day for installation assistance and inspection.
 - b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
 - c. 1 person-day for prestart-up classroom or Site training.
- B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

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- C. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this specification:
 - 1. Slide Gate Schedule.
 - 2. Stop Log Schedule.

END OF SECTION

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Slide Gate Schedule						
Gate Identification No. and Location	Assembly Style ¹	Wall Opening (width/height inches)	Gate Height (inches)	Flow Stream	Design Operating Head (feet) Seating/Unseating Condition	Operator Type/ Control Style
55G1230 - UV Channel 1 Influent Gate ³	Style B ²	65/92	74	SE	7/7	Operator Type 4 Electric Open/Close with Remote Hand Station Control Style 3
55G2230 - UV Channel 2 Influent Gate ³	Style B ²	65/92	74	SE	7/7	Operator Type 4 Electric Open/Close with Remote Hand Station Control Style 3
Note: ¹See the Drawings for configuration and invert elevations. ²Self-contained gate. ³Provide splice in frame as required to allow for slide/seal removal/replacement. Provide frame reinforcing and bracing to concrete floor as required to accommodate splice. Provide structural calculations for frame.						

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Stop Log Schedule						
Facility	No. of Frames Required	Frame Type ¹	Wall/Channel Opening, Width x Height (inches)	Min. Installed Height (inches) ²	Flow Stream	Design Operating Head (feet) Seating Unseating Condition
55 - UV Channel 2 Inlet	1	Face Mounted	65 X 170	170	SE	13.5/13.5
55 – UV Channel 2 Outlet	1	Embedded, Channel Type	65 X 110	110	PLE	4.5/4.5
Note: ¹ See the Drawings for configuration and invert elevations. ² Provide number of stop logs required to isolate a single channel.						

SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:
1. Air Force: A-A-58092, Tape, Antiseize, Polytetrafluorethylene.
 2. American Society of Mechanical Engineers (ASME):
 - a. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
 - b. B1.20.1, Pipe Threads, General Purpose (Inch).
 - c. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
 - d. B16.9, Factory-Made Wrought Buttwelding Fittings.
 - e. B16.11, Forged Fittings, Socket-Welding and Threaded.
 - f. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
 - g. B16.25, Buttwelding Ends.
 - h. B31.1, Power Piping.
 - i. B31.3, Process Piping.
 - j. B36.10M, Welded and Seamless Wrought Steel Pipe.
 3. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.
 4. American Water Works Association (AWWA):
 - a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
 - d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
 - g. C153/A21.53, Ductile-Iron Compact Fittings.
 - h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 Inches Through 144 Inches (100 mm Through 3,600 mm).
 - i. C606, Grooved and Shouldered Joints.

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- j. C906, Polyethylene (PE) Pressure Pipe & Fittings, 4-inch through 63-inch for Water Distribution.
- 5. American Welding Society (AWS):
 - a. Brazing Handbook.
 - b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
 - c. D1.1/D1.1M, Structural Welding Code - Steel.
 - d. QC1, Standard for AWS Certification of Welding Inspectors.
- 6. ASTM International (ASTM):
 - a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - b. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
 - c. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
 - d. A139/A139M, Standard Specification for Electro-Fusion (Arc)-Welded Steel Pipe (NPS 4 Inches and Over).
 - e. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
 - f. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - g. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - h. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
 - i. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 pounds per square inch Tensile Strength.
 - j. A563, Standard Specification for Carbon and Alloy Steel Nuts.
 - k. B32, Standard Specification for Solder Metal.
 - l. D1330, Standard Specification for Rubber Sheet Gaskets.
 - m. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
 - n. D2657, Standard Practice for Heat Joining of Polyolefin Pipe and Fittings.
 - o. D3261, Standard Practice for Butt Heat Fusion Polyethylene (PE) Plastic Fittings, Pipe and Tubing.
 - p. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
 - q. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - r. F1290, Electrofusion Joining of Polyolefin Pipe and Fittings.

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- s. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, Schedule 80, and Schedule 120.
- t. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- u. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- v. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- w. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
- x. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- 7. FM Global (FM).
- 8. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.
- 9. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
- 10. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.02 DEFINITIONS

- A. Submerged or Wetted: Zone below elevation of top face of channel walls and cover slabs.

1.03 DESIGN REQUIREMENTS

- A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:
 - 1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
 - 2. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
 - 3. Thrust Restraints:
 - a. Design for test pressure shown in Piping Schedule.
 - b. Allowable Soil Pressure: 1,000 pounds per square foot.
 - c. Low Pressure Pipelines:
 - 1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.

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- 2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
 - a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
 - b. Layout Drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Dissimilar Buried Pipe Joints: Joint types and assembly Drawings.
5. Pipe Corrosion Protection: Product data.

B. Informational Submittals:

1. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torquing requirements and bolt tightening procedures.
2. Qualifications:
 - a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
 - b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
 - c. Welders:
 - 1) Continuity log for welders and welding operators.
 - 2) Welder qualification test records conducted by Contractor or manufacturer.
3. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Test logs.
6. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

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7. Torquing requirements and procedures, including torque values, for flanged piping assemblies.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
 - a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
 - b. Calibrated instruments and equipment and documented standard procedures for performing specified testing.
 - c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
 - d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
 - e. Verification Welding Inspector: AWS QC1 Certified.
2. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
3. Contractor's CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Special inspection to be provided by Owner and performed by independent inspection and testing agency for welding operations.

1. The presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

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PART 2 PRODUCTS

2.01 GENERAL

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

2.02 PIPING

- A. As specified on Piping Data Sheet(s) and on Piping Schedule located on the Drawings.
- B. Diameters Shown:
 - 1. Standardized Products: Nominal size.
 - 2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
 - 3. Cement-Lined Steel Pipe: Lining inside diameter.

2.03 JOINTS

- A. Flanged Joints:
 - 1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
 - 2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher-pressure rating than required for piping.
- B. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through-flanged connections consisting of the following:
 - 1. Polyethylene stub end thermally butt-fused to end of pipe.
 - 2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Use insulating flanges where shown.

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3. Bolts and nuts of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard.
Retorque nuts after 4 hours.
4. Gaskets as specified on Data Sheet.

2.04 GASKET LUBRICANT

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

2.05 PIPE CORROSION PROTECTION

- A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.
- B. Polyethylene Encasement (Bagging):
 1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.
 2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1-inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.
- C. Insulating Flanges, Couplings, and Unions:
 1. Materials:
 - a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.9 working pressure rating equal to or higher than that of joint and pipeline.
 - b. Galvanically compatible with piping.
 - c. Resistant for intended exposure, operating temperatures, and products in pipeline.
 2. Union Type, 2 Inches and Smaller:
 - a. Screwed or solder-joint.
 - b. O-ring sealed with molded and bonded insulation to body.
 3. Flange Type, 2-1/2 Inches and Larger:
 - a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
 - b. Bolt insulating sleeves shall be provided full length between insulating washers.
 - c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.

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- d. AWWA C207 steel flanges may be drilled oversize up to 1/8 inch to accommodate insulating sleeves.

2.06 FABRICATION

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

2.07 FINISHES

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

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

- A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.
- B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

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- C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.
- D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

3.03 INSTALLATION—GENERAL

- A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
- B. Remove foreign objects prior to assembly and installation.
- C. Flanged Joints:
 - 1. Install perpendicular to pipe centerline.
 - 2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
 - 3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
 - 4. Manufacturer: Same as pipe manufacturer.
- D. Threaded and Coupled Joints:
 - 1. Conform to ASME B1.20.1.
 - 2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
 - 3. Countersink pipe ends, ream and clean chips and burrs after threading.
 - 4. Make connections with not more than three threads exposed.
 - 5. Lubricate male threads only with thread lubricate or tape as specified on Piping Data Sheets.
- E. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.
- F. PVC Piping:
 - 1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
 - 2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
 - 3. Do not thread Schedule 40 pipe.

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G. Ductile Iron Piping:

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

H. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

3.04 INSTALLATION—BURIED PIPE

A. Joints:

1. Dissimilar Buried Pipes:
 - a. Provide flexible mechanical compression joints for pressure pipe.
 - b. Provide concrete closure collar for piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.

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7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
 - a. Shorter pipe lengths.
 - b. Special mitered joints.
 - c. Standard or special fabricated bends.
10. After joint has been made, check pipe alignment and grade.
11. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
12. Prevent uplift and floating of pipe prior to backfilling.

C. PVC or HDPE Placement:

1. Lay pipe snaking from side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, except PVC or HDPE Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.05 INSTALLATION – CONCRETE ENCASED

- A. Provide reinforced concrete pipe encasement where shown on the Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on the Drawings for encasement requirements.

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- B. Where concrete encased piping crosses structure expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.06 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

- 1. Buried: Wrap with polyethylene bagging.
- 2. Submerged or Embedded: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service use NSF 61 approved epoxy.

B. Carbon Steel Pipe:

- 1. Buried:
 - a. Pipe: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating.
 - b. Joints: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating.
- 2. Submerged or Embedded: Shop coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF 61 approved epoxy.

C. Piping Accessories:

- 1. Buried:
 - a. Ferrous Metal and Stainless Steel Components: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating.
 - b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
 - c. Flexible Couplings and Similar Items: Wrap with heat shrink wrap.
 - d. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

D. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer's instructions.

E. Tape Coating System: As specified in Section 09 90 00, Painting and Coating.

F. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.

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G. Insulating Flanges, Couplings, and Unions:

1. Applications:
 - a. Dissimilar metal piping connections.
 - b. Cathodically protected piping penetration to watertight structures.
 - c. Where required for electrically insulated connection.
2. Pipe Installation:
 - a. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
 - b. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.07 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.

B. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

C. Thrust Blocking:

1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.08 FIELD FINISHING

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

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3.09 PIPE IDENTIFICATION

- A. As specified in Section 10 14 00, Signage, Section 31 23 23.15, Trench Backfill, and Section 09 90 00, Painting and Coating.

3.10 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.
- B. Minimum Duties of Welding Inspector:
 - 1. Job material verification and storage.
 - 2. Qualification of welders.
 - 3. Certify conformance with approved welding procedures.
 - 4. Maintenance of records and preparation of reports in a timely manner.
 - 5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.
- C. Required Weld Examinations:
 - 1. Perform examinations in accordance with Piping Code.
 - 2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
 - 3. Examine at least one of each type and position of weld made by each welder or welding operator.
 - 4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.11 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, to assist with unloading of the double wall containment piping system, system tests, containment pipe joint closure. Manufacturer's representative shall complete a Manufacturer's Certificate of Proper Installation. Inspection and examination practices shall be according to ASME B31.3 for Normal Fluid Service.

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3.12 CLEANING

- A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.
- B. Immediately after cleaning service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.
- C. If impractical to flush large diameter pipe at 2.5 fps or blow at fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.
- D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.
- E. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.13 SUPPLEMENTS

- A. Refer to Piping Schedule on the Drawings.
- B. The supplements listed below, following “End of Section,” are a part of this specification:

1. Data Sheets.

Number	Title
40 27 00.01	Lined Ductile Iron Pipe and Fittings
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings

END OF SECTION

SALMON CREEK TREATMENT PLANT
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SECTION 40 27 00.01 LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA C151/A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Buried Liquid Service Using Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 3 and Table 5 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Buried Air Service Using Proprietary Restrained Joints: AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4 with asphaltic seal coat. Use only for liquid service.

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SECTION 40 27 00.01 LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
Fittings	Lined and coated same as pipe. Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.
Joints	Proprietary Restrained: 250 psi minimum working pressure. American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex or HP Lok. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Dimensions per AWWA C110/A21.10 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.

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SECTION 40 27 00.01 LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Flanged: ASTM A307, Grade B carbon steel heavy hex head or stud bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations.
Gaskets	General: Gaskets in contact with potable water shall be NSF ANSI 61 certified. Proprietary Restrained Joints; Water and Sewage Service: Halogenated butyl or EPDM, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Proprietary Restrained Joints; Hot Air Service: EPDM or Viton, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: Full face, 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D1330. Blind flanges shall be epoxy-lined in accordance with the system specified above. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	Size	Description
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	Size	Description
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium hypochlorite and chlorine solution service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service, IPS Weld-On 724, "or-equal." Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
 - a. Submit prior to testing and include at least the information that follows.
 - 1) Testing dates.
 - 2) Piping systems and section(s) to be tested.
 - 3) Test type.
 - 4) Method of isolation.
 - 5) Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

- A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
- B. Pressure Piping:
 1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
 2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
 3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
 4. New Piping Connected to Existing Piping: Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.

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5. Items that do not require testing include:
 - a. Equipment seal drains, tank overflows to atmospheric vented drains, tank atmospheric vents.
 6. Test Pressure: As indicated on Pipe Schedule as shown on the Drawings.
- C. Test section may be filled with water and allowed to stand under low pressure prior to testing.
- D. Gravity Piping:
1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
 2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
 3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

- A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.
- B. Exposed Piping:
1. Perform testing on installed piping prior to application of insulation.
 2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
 3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
 4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
 5. Examine joints and connections for leakage.
 6. Correct visible leakage and retest as specified.
 7. Leave pipe full of water after repair of leaks.
- C. Buried Piping:
1. Test after backfilling has been completed.
 2. Expel air from piping system during filling.
 3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.

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4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{148,000}$$

where:

L	=	Allowable leakage, in gallons per hour.
S	=	Length of pipe tested, in feet.
D	=	Nominal diameter of pipe, in inches.
P	=	Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 HYDROSTATIC TEST FOR GRAVITY PIPING

- A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.
- B. Maximum Allowable Leakage: 0.16 gallon per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.
- C. Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.
- D. Exfiltration Test:
 1. Hydrostatic Head:
 - a. At least 6 feet above maximum estimated groundwater level in section being tested.
 - b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
 2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

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- E. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.
- F. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified article.

3.04 FIELD QUALITY CONTROL

A. Test Report Documentation:

- 1. Test date.
- 2. Description and identification of piping tested.
- 3. Test fluid.
- 4. Test pressure.
- 5. Remarks, including:
 - a. Leaks (type, location).
 - b. Repair/replacement performed to remedy excessive leakage.
- 6. Signed by Contractor to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

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

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1.02 SUMMARY

A. Work Includes:

1. Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for complete Process Instrumentation and Control (PIC) for new package system.
2. Major parts are:
 - a. Installation of instrumentation provided as part of UV Package System, see Section 01 31 15, Construction Sequencing and Constraints.
 - b. Wiring and testing of the new UV Package system components and instrumentation, see Section 01 31 15, Construction Sequencing and Constraints.
 - c. Installation, wiring, and testing of control signals of the new influent and effluent gates, see Section 01 31 15, Construction Sequencing and Constraints.
 - d. Installation, wiring, and testing of new redundant level transmitters used to calculate flow through the channels, see Section 01 31 15, Construction Sequencing and Constraints.
 - e. The actuator for FV-202 shall be replaced and new control wiring shall be provided. The new actuator shall provide the same four discrete signals to the PLC as the previous actuator. These signals are wired to 55LCP0200. PICs shall perform Functional Test Part 1 on the new wiring between FV-202 and 55LCP0200.
 - f. Functional Testing shall be performed on all new and replaced control wiring associated with the relocation of equipment.
 - g. PICS to support Owners System Integrator during Functional Testing and PAT.

B. Work by Others:

1. UV Package System:
 - a. Package system provided by others including System Control Center, Power Distribution Centers, Hydraulic System Centers, UV Banks, UV system application software, and instrumentation as indicated on P&ID.
 - b. Integration of Package System Application Software and Plant PLC and HMI modifications will be done by Owners System Integrator under a separate contract.

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

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1.03 DEFINITIONS

A. Abbreviations:

1. LCP: Local Control Panel.
2. MCC: Motor Control Center.
3. PAT: Performance Acceptance Test.
4. PIC: Process Instrumentation and Control.
5. PLC: Programmable Logic Controller.

B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

C. Signal Types:

1. Analog Signals, Current Type:
 - a. 4 mA dc to 20 mA dc signals conforming to ISA S50.1.
 - b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
 - 1) Transmitter Type: Number 2, two-wire.
 - 2) Transmitter Load Resistance Capacity: Class L.
 - 3) Fully isolated transmitters and receivers.
2. Discrete signals, two-state logic signals using 120V ac sources.
3. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

D. Instrument Tag Numbers: See the Drawings for tag numbers.

1.04 SUBMITTALS

A. Action Submittals:

1. General:
 - a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.
 - b. Identify proposed items and options. Identify installed spares and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).

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- c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).
2. Bill of Materials: List of required equipment.
 - a. Group equipment items as follows:
 - 1) I&C Components: By component identification code.
 - 2) Other Equipment: By equipment type.
 - b. Data Included:
 - 1) Equipment tag number.
 - 2) Description.
 - 3) Manufacturer, complete model number, and all options not defined by model number.
 - 4) Quantity supplied.
 - 5) Component identification code where applicable.
3. Catalog Cuts:
 - a. I&C Components, Electrical Devices, and Mechanical Devices:
 - 1) Catalog information, mark to identify proposed items and options.
 - 2) Descriptive literature.
 - 3) External power and signal connections.
 - 4) Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
4. Component Data Sheets: Data sheets for I&C components.
 - a. Format and Level of Detail: In accordance with ISA-S20.
 - b. Include component type identification code and tag number on data sheet.
 - c. Specific features and configuration data for each component:
 - 1) Location or service.
 - 2) Manufacturer and complete model number.
 - 3) Size and scale range.
 - 4) Setpoints.
 - 5) Materials of construction.
 - 6) Options included.
 - d. Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
5. Panel Wiring Diagrams: Show point-to-point and terminal-to-terminal wiring within panel.
6. Loop Diagrams: Individual wiring diagram for each analog or pulse frequency loop.
 - a. Conform to the minimum requirements of ISA S5.4.
 - b. Under Paragraph 5.3 of ISA S5.4, include the information listed under subparagraphs 2 and 6.
 - c. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.

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- d. Divide each loop diagram into areas for panel face, back-of-panel, and field.
 - e. Show:
 - 1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
 - 2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
 - 3) Tabular summary on each diagram:
 - a) Transmitting Instruments: Output capability.
 - b) Receiving Instruments: Input impedance.
 - c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
 - d) Total loop impedance.
 - e) Reserve output capacity.
 - 4) Circuit and raceway schedule names.
 - 7. Installation Details: Include modifications or further details required to adequately define installation of I&C components not provided as part of the UV Package System.
 - 8. List of spares, expendables, test equipment and tools.
 - 9. Additional Equipment Recommended: List of, and descriptive literature for, additional spares, expendables, test equipment and tools recommended. Include unit prices and total costs as specified in Section 01 29 00, Payment Procedures.
- B. Informational Submittals: For PIC equipment not provided as part of the UV Package System, provide Manufacturer's Certificate of Proper Installation and readiness for operation.
- 1. Owner Training Plan. Reference Section 01 43 33, Manufacturers' Field Services.
 - 2. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
 - a. Content and Format:
 - 1) Complete sets O&M manuals.
 - 2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PIC component.
 - 3) Final versions of Legend and Abbreviation Lists.
 - 4) Manual format in accordance with Section 01 78 23, Operation and Maintenance Data.

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- b. Include:
 - 1) Process and Instrumentation Diagrams: One reproducible copy of revised P&ID to reflect as-built PIC design.
 - 2) Refer to paragraph Shop Drawings for the following items:
 - a) Bill of Materials.
 - b) Catalog Cuts.
 - c) Component Data Sheets.
 - d) Panel Wiring Diagrams, one reproducible copy.
 - e) Loop Diagrams, one reproducible copy.
 - 3) Device O&M manuals for components, electrical devices, and mechanical devices include:
 - a) Operations procedures.
 - b) Installation requirements and procedures.
 - c) Maintenance requirements and procedures.
 - d) Troubleshooting procedures.
 - e) Calibration procedures.
 - f) Internal schematic and wiring diagrams.
 - g) Component Calibration Sheets from field quality control calibrations.
 - 4) List of spares, expendables, test equipment and tools provided.
 - 5) List of additional spares, expendables, test equipment and tools recommended.
- 3. Performance Acceptance Tests (PAT) Submittals:
 - a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
 - b. Final Test Procedures: Proposed test procedures, forms, and checklists.
 - c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.05 QUALITY ASSURANCE

- A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.
- B. Coordination Meetings:
 - 1. In accordance with Section 01 31 13, Project Coordination.
 - 2. Location: Project site.
 - 3. Attended By: Engineer, Owner, and Contractor.

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4. Minimum of one is required. Specific dates will be established in Progress Schedule.
5. First Meeting: Within 36 days after Notice to Proceed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Provide Site storage facilities for PIC equipment.
- B. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- C. Cover panels and other elements that are exposed to dusty construction environments.

1.07 SEQUENCING AND SCHEDULING

- A. Activity Completion:
 1. The following is a list of key activities and their completion criteria:
 - a. Quality Control Submittals: Reviewed and accepted.
 - b. PAT: Completed and required test documentation accepted.
- B. PIC Substantial Completion: When Engineer issues Certificate of Substantial Completion.
 1. Prerequisites:
 - a. All PIC Submittals have been completed.
 - b. PIC has successfully completed PAT.
 - c. Owner training plan is on schedule.
 - d. All spares, expendables, and test equipment have been delivered to Owner.
- C. PIC Acceptance: When Engineer issues a written notice of Final Payment and Acceptance.
 1. Prerequisites:
 - a. Certificate of Substantial Completion issued for PIC.
 - b. Punch-list items completed.
 - c. Final revisions to O&M manuals accepted.
 - d. Maintenance service agreements for PIC accepted by Owner.

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D. Prerequisite Activities and Lead Times:

1. Do not start the following key Project activities until the prerequisite activities and lead times listed below have been completed and satisfied:

Activity	Prerequisites and Lead Times
Submittal reviews by Engineer	Engineer acceptance of Submittal breakdown and schedule.
Instrumentation purchasing	Associated Submittals completed.
Owner Training	Owner training plan completed
PAT	Startup, Owner training, and PAT procedures completed; notice 4 weeks prior to start.

PART 2 PRODUCTS

2.01 GENERAL

- A. PIC functions as shown on the Drawings and as required for each loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.
- B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment and materials.
 1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with Article Submittals.
 2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.
- C. Like Equipment Items:
 1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
 2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

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2.02 I&C COMPONENTS

A. L29 Level Element and Transmitter, Radar:

1. General:
 - a. Function: Continuous level measurement.
 - b. Type: Radar, noncontacting.
 - c. Loop powered.
 - d. Parts: Element/integral transmitter and accessories as noted.
2. Service:
 - a. Operating Temperature Range:
 - 1) Ambient: Minus 40 degrees F to plus 176 degrees F.
 - 2) Pressure Rating:
 - a) Dependent on antenna type and process temperature.
 - b) For PTFE rod with PVDF threaded connection, minus 14 pounds per square inch gauge to plus 43.5 pounds per square inch gauge.
3. Performance:
 - a. Process Range: As noted.
 - b. Zero Reference: As noted.
 - c. Frequency: C-band.
 - d. Accuracy (maximum measurement error): Plus or minus 2 millimeters (0.08 inch).
 - e. Resolution: 0.04 inch (1 millimeter.)
 - f. Medium Suitability:
 - 1) Suitable for most liquids with measuring range decreasing for liquids with smaller dielectric constants.
 - 2) For conductive liquids, (for example, water) maximum possible measuring range is 65 feet.
4. Element/Integral Transmitter:
 - a. Enclosure:
 - 1) Transmitter: NEMA 4X/IP65 watertight.
 - 2) Antenna: NEMA 6P/IP68.
 - b. Display: None.
 - c. Antenna Parameters:
 - 1) Size: 3 inches.
 - 2) Material: PVDF body.
 - d. Process Connection: 1-inch NPT Threads.
 - e. Approvals:
 - 1) FM Intrinsic Intrinsically Safe, Class I, Div 1, Group A-D: If noted.
 - 2) FM, Explosion-proof, Class I, Div 1, Group A-D: If noted.
 - 3) Others: As noted.
 - f. Element Beam Angle: 12 degrees.

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5. Signal and Electrical Interface:
 - a. Analog: 4 mA dc to 20 mA dc.
6. Accessories:
 - a. Cantilever with wall mounting bracket.
 - b. Flooding protection tube.
7. Manufacturer and Product: Endress and Hauser Micropilot M FMR20.

2.03 NAMEPLATES AND TAGS

- A. Service Legends: Component identification nameplate located on face of component.
 1. Inscription: As shown.
 2. Materials: Adhesive backed, laminated plastic.
 3. Letters: 3/16 inch white on black background, unless otherwise noted.
- B. Nametags: Component identification for field devices.
 1. Inscription: Component tag number.
 2. Materials: 16-gauge, Type 304 stainless steel.
 3. Letters: 3/16 inch imposed.
 4. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire or stainless steel screws.

2.04 ELECTRICAL REQUIREMENTS

- A. In accordance with Division 26, Electrical.
- B. I&C and electrical components, terminals, wires, and enclosures: UL recognized or UL listed.
- C. Wires within Enclosures:
 1. ac Circuits:
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than 18 AWG.
 2. Analog Signal Circuits:
 - a. Type: 300-volt stranded copper, twisted shielded pairs.
 - b. Size: 18 AWG, minimum.
 3. Other dc Circuits.
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current carried, but not less than 18 AWG.
 4. Special Signal Circuits: Use manufacturer's standard cables.

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- 5. Wire Identification: Numbered and tagged at each termination.
 - a. Wire Tags: Machine printed, heat shrink.
 - b. Manufacturers:
 - 1) Brady PermaSleeve.
 - 2) Tyco Electronics.
- D. Wires entering or leaving enclosures, terminate and identify as follows:
 - 1. Analog and discrete signal, terminate at numbered terminal blocks.
 - 2. Special signals, terminated using manufacturer's standard connectors.
 - 3. Identify wiring in accordance with Section 26 05 05, Conductors.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Material and Equipment Installation: Retain a copy of manufacturers' instructions at Site, available for review at all times.
- B. Electrical Wiring: As specified in Division 26, Electrical.
- C. Mechanical Systems: The Drawings for PIC Mechanical Systems are diagrammatic and not intended to specifically define element locations or piping and tubing run lengths. Base materials and installations on field measurements.
- D. Removal or Relocation of Materials and Equipment:
 - 1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
 - 2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

SALMON CREEK TREATMENT PLANT
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3.03 FIELD FINISHING

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

3.04 FIELD QUALITY CONTROL

A. General:

1. Coordinate PIC testing with Owner, Owners System Integrator, and affected Subcontractors.
2. Notify Engineer and Owners System Integrator of Performance Test schedule 4 weeks prior to start of test.
3. Engineer may actively participate in tests.
4. Engineer reserves right to test or retest specified functions.
5. Engineer's decision will be final regarding acceptability and completeness of testing.

B. Onsite Supervision:

1. PIC Contractor to observe PIC equipment installation to extent required in order to provide Certificates of Proper Installation.
2. PIC site representative to supervise and coordinate onsite PIC activities.
3. PIC site representative to be onsite while onsite work covered by this section and PIC subsystems is in progress.

C. Testing:

1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PIC equipment is ready for operation. Divide Functional Test for each facility into two parts.
2. Functional Test Part 1: Performed by the PIC Contractor to test and document PIC, excluding Owners System Integrator provided applications software, is ready for operation.
 - a. Loop/Component Inspections and Tests:
 - 1) These inspections and tests will be spot checked by Engineer.
 - 2) Check PIC for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
 - 3) Provide space on forms for signoff by PIC Contractor.

SALMON CREEK TREATMENT PLANT
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- 4) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
 - a) Project name.
 - b) Loop number.
 - c) Tag number for each component.
 - d) Checkoffs/Signoffs for Each Component:
 - (1) Tag/identification.
 - (2) Installation.
 - (3) Termination wiring.
 - (4) Termination tubing.
 - (5) Calibration/adjustment.
 - e) Checkoffs/Signoffs for the Loop:
 - (1) Panel interface terminations.
 - (2) I/O interface terminations with PLCs.
 - f) I/O Signals for PLCs are Operational: Received/sent, processed.
 - g) Total loop operational.
 - h) Space for comments.
- 5) Component calibration sheet for each active I&C component (except simple hand switches, lights, gauges, and similar items) and each PLC I/O module, and include the following:
 - a) Project name.
 - b) Loop number.
 - c) Component tag number or I/O module number.
 - d) Component code number for I&C elements.
 - e) Manufacturer for I&C elements.
 - f) Model number/serial number for I&C elements.
 - g) Summary of Functional Requirements; for example:
 - (1) Indicators scale ranges.
 - (2) Transmitters/converters, input, and output ranges.
 - (3) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
 - (4) I/O Modules: Input or output.
 - h) Calibrations, for example, but not limited to:
 - (1) Analog Devices: Actual inputs and outputs at 0 percent, 50 percent, and 100 percent of span, rising and falling.
 - (2) Discrete Devices: Actual trip points and reset points.

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- (3) I/O Modules: Actual inputs or outputs of 0 percent, 50 percent, and 100 percent of span, rising and falling.
 - (4) Space for comments.
 - b. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
 - c. Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.
 - d. FDT-Repeat:
 - 1) Repeat FDT onsite with installed PIC equipment and software.
 - 2) Use FDT test procedures as basis for this test.
 - 3) In general, this test shall not require witnessing. However, portions of this test, as identified by Engineer during original FDT shall be witnessed.
 - e. Forms: See Loop Status Report and Instrument Calibration Sheet referenced in Article Supplements.
- 3. Functional Test Part 2: Combined effort between Contractor, PIC Contractor, Owners System Integrator and Engineer to confirm PIC, including applications software, is ready for operation.
 - a. Prerequisite: Completion of Functional Test Part 1.
 - b. Joint test with Owners System Integrator and Engineer. Test using real field sensors and equipment. Plant interlocking and communications with PLCs and HMI tested on loop-by-loop basis.
 - c. Test procedures provided by Engineer based on Functional Test Part 1 and on application software tests.
 - d. Completed when Functional Test has been conducted and Engineer has checked associated test forms and checklists in field.
- 4. Required Test Documentation: Test procedures, forms, and checklists. Signed by Contractor.

D. Performance Test During and After Facility Startup:

- 1. Once a facility's Functional Test has been completed and that facility has been started up, perform jointly with Owners System Integrator and Engineer a Performance Test on associated PIC equipment to demonstrate that it is operating as required by Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.
- 2. Make loop-specific and nonloop-specific tests on entire installed PIC using actual process variables and functions demonstrated.

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3. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
4. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
5. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.
6. Make O&M data available to Engineer at Site both before and during testing.
7. Determination of Ready for Operation: When Functional Test has been completed.
8. Refer to examples of Performance Test procedures and forms in Article Supplements.

3.05 TRAINING

A. General:

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

B. Operations and Maintenance Training:

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

SALMON CREEK TREATMENT PLANT
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3.06 CLEANING/ADJUSTING

- A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.
- B. Cleaning: Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.07 PROTECTION

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

3.08 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this specification:
 - 1. Instrument List.
 - 2. PLC Input and Output List.
 - 3. Instrument Calibration Sheet: Provides detailed information on each instrument (except simple hand switches, lights, and similar items).
 - 4. Performance Acceptance Test Sheet: Describes the PAT for a given loop. The format is mostly free form.
 - a. Lists the requirements of the loop.
 - b. Briefly describes the test.
 - c. Cites expected results.
 - d. Provides space for check off by witness.

END OF SECTION

INSTRUMENT LIST

Tag Number	Component Code	Component Title	Description	Options	P&ID	Installation Detail
55AIT-FIT1260A	L29	Level Element and Transmitter, Radar	UV Channel 1 Effluent Level A	1. Cantilever with wall mounting bracket 2. Flooding protection tube	95-I-124	4091-254
55AIT-FIT1260B	L29	Level Element and Transmitter, Radar	UV Channel 1 Effluent Level B	1. Cantilever with wall mounting bracket 2. Flooding protection tube	95-I-124	4091-254
55AIT-FIT2260A	L29	Level Element and Transmitter, Radar	UV Channel 2 Effluent Level A	1. Cantilever with wall mounting bracket 2. Flooding protection tube	95-I-124	4091-254
55AIT-FIT2260B	L29	Level Element and Transmitter, Radar	UV Channel 2 Effluent Level B	1. Cantilever with wall mounting bracket 2. Flooding protection tube	95-I-124	4091-254

PLC Input and Output List

Control Panel	PLC	I/O Tag	Description	Zero State	One State	I/O Type	P&ID
55LCP0001	55PLC02	55ZT1250_POS	UV Channel No. 1 Effluent Gate Position Feedback	0	100	AI	95-I-124
55LCP0001	55PLC02	55FIT1260A_FLOW	UV Channel No. 1 Effluent Level A			AI	95-I-124
55LCP0001	55PLC02	55FIT1260B_FLOW	UV Channel No. 1 Effluent Level B			AI	95-I-124
55LCP0001	55PLC02	55ZT2250_POS	UV Channel No. 2 Effluent Gate Position Feedback	0	100	AI	95-I-124
55LCP0001	55PLC02	55FIT2260A_FLOW	UV Channel No. 2 Effluent Level A			AI	95-I-124
55LCP0001	55PLC02	55FIT2260B_FLOW	UV Channel No. 2 Effluent Level B			AI	95-I-124
55LCP0001	55PLC02	55AIT0605_UVT	UV Channel UVT			AI	95-I-124

Total AI: 7

Control Panel	PLC	I/O Tag	Description	Zero State	One State	I/O Type	P&ID
55LCP0001	55PLC02	55G1250_POS	UV Channel No. 1 Effluent Gate Position Setpoint	0	100	AO	95-I-124
55LCP0001	55PLC02	55FIT1260_FLOW	UV Channel No. 1 Effluent Flow			AO	95-I-124
55LCP0001	55PLC02	55G2250_POS	UV Channel No. 2 Effluent Gate Position Setpoint	0	100	AO	95-I-124
55LCP0001	55PLC02	55FIT2260_FLOW	UV Channel No. 2 Effluent Flow			AO	95-I-124

Total AO: 4

Control Panel	PLC	I/O Tag	Description	Zero State	One State	I/O Type	P&ID
55LCP0001	55PLC02	55HS1230B_REM	UV Channel No. 1 Influent Gate Remote	Local	Remote	DI	95-I-124
55LCP0001	55PLC02	55G1230B_OPEN	UV Channel No. 1 Influent Gate Open		Open	DI	95-I-124
55LCP0001	55PLC02	55G1230B_CLOSE	UV Channel No. 1 Influent Gate Close		Close	DI	95-I-124
55LCP0001	55PLC02	55HS1250B_REM	UV Channel No. 1 Effluent Gate Remote	Local	Remote	DI	95-I-124
55LCP0001	55PLC02	55HS2230B_REM	UV Channel No. 2 Influent Gate Remote	Local	Remote	DI	95-I-124
55LCP0001	55PLC02	55G2230B_OPEN	UV Channel No. 2 Influent Gate Open		Open	DI	95-I-124
55LCP0001	55PLC02	55G2230B_CLOSE	UV Channel No. 2 Influent Gate Close		Close	DI	95-I-124
55LCP0001	55PLC02	55HS2250B_REM	UV Channel No. 2 Effluent Gate Remote	Local	Remote	DI	95-I-124

Total DI: 8

Control Panel	PLC	I/O Tag	Description	Zero State	One State	I/O Type	P&ID
55LCP0001	55PLC02	55HS1230B_OPENED	UV Channel No. 1 Influent Gate Opened		Opened	DO	95-I-124
55LCP0001	55PLC02	55HS1230B_CLOSED	UV Channel No. 1 Influent Gate Closed		Closed	DO	95-I-124
55LCP0001	55PLC02	55HS2230B_OPENED	UV Channel No. 2 Influent Gate Opened		Opened	DO	95-I-124
55LCP0001	55PLC02	55HS2230B_CLOSED	UV Channel No. 2 Influent Gate Closed		Closed	DO	95-I-124

Total DO: 4

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

JACOBS

INSTRUMENT CALIBRATION SHEET

Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT					
Code:			Name:				Number:					
Name:			Model:				Name:					
			Serial #:									
FUNCTIONS												
Indicate? Y / N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? Y / N			CONTROL? Y / N					
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D					
Record? Y / N	Scale:						SWITCH? Y / N					
Transmit/ Convert? Y / N	Input:						Unit Range:					
	Output:						Differential: fixed/adjustable Reset? automatic / manual					
ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS				Note No.	
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED		
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point		Reset Pt.
			Indicated	Output	Indicated	Output		(note rising or falling)		(note rising or falling)		
							1.					
							2.					
							3.					
							4.					
							5.					
							6.					
CONTROL MODE SETTINGS:			P:	I:	D:		7.					
#	NOTES:								Component Calibrated and Ready for Startup			
									By:			
									Date:			
									Tag No.:			

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

JACOBS

INSTRUMENT CALIBRATION SHEET
EXAMPLE - ANALYZER/TRANSMITTER

Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT				
Code: A7			Name: Leeds & Northrup				Number: WDC30715.B2				
Name: pH Element & Analyzer/Transmitter			Model: 12429-3-2-1-7				Name: UOSA AWT PHASE 3				
			Serial #: 11553322								
FUNCTIONS											
Indicate? Y Record? N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N			CONTROL? N				
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D				
	Scale:	1-14	pH units				SWITCH? N				
Transmit/ Convert? Y	Input:	1-14	pH units				Unit Range:				
	Output:	4-20	mA dc				Differential: fixed/adjustable Reset? automatic / manual				
ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS				Note No
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED	
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.
			Indicated	Output	Indicated	Output		(note rising or falling)		(note rising or falling)	
1.0	1.0	4.0	1.0	4.0	1.0	3.9	1.	N.A.		N.A.	
2.3	2.3	5.6	2.2	5.5	2.3	5.6	2.				
7.5	7.5	12.0	7.5	11.9	7.5	12.0	3.				
12.7	12.7	18.4	12.7	18.3	12.6	18.3	4.				
14.0	14.0	20.0	14.0	20.0	14.0	20.0	5.				
							6.				
CONTROL MODE SETTINGS:			P: N.A.	I:	D:		7.				
#	NOTES:									Component Calibrated and Ready for Startup	
	1. Need to recheck low pH calibration solutions.									By: J.D. Sewell	
										Date: Jun-6-92	
										Tag No.: AIT-12-6[pH]	

JACOBS **PERFORMANCE ACCEPTANCE TEST SHEET** *Rev.06.05.92*

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SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

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PERFORMANCE ACCEPTANCE TEST SHEET

Rev.06.05.92

EXAMPLE

Project Name: <i>SFO SEWPCP Plant Expansion</i>		Project No.: <i>SFO12345.C1</i>																										
Demonstration Test(s): For each functional requirement of the loop: (a) List and number the requirement. (b) Briefly describe the demonstration test. (c) Cite the results that will verify the required performance. (d) Provide space for signoff.																												
<i>1. MEASURE EFFLUENT FLOW</i>																												
<i>1.a With no flow, water level over weir should be zero and</i>																												
<i>FIT indicator should read zero.</i>			<i>Jun-20-92 BDG</i>																									
<i>2. FLOW INDICATION AND TRANSMISSION TO LP & CCS</i>																												
<i>With flow, water level and FIT indicator should be related by expression</i>																												
<i>$Q(\text{MGD}) = 429 \cdot H^{2/3}$ (H = height in inches of water over weir).</i>																												
<i>Vary H and observe that following.</i>																												
<i>2.a Reading of FIT indicator.</i>			<i>Jun-6-92 BDG</i>																									
<i>2.b Reading is transmitted to FI on LP-521-1.</i>			<i>Jun-6-92 BDG</i>																									
<i>2.c Reading is transmitted and displayed to CCS.</i>			<i>Jun-6-92 BDG</i>																									
<table border="1"> <tr> <td><i>H(measured)</i></td> <td><i>0</i></td> <td><i>5</i></td> <td><i>10</i></td> <td><i>15</i></td> </tr> <tr> <td><i>Q(computed)</i></td> <td><i>0</i></td> <td><i>47.96</i></td> <td><i>135.7</i></td> <td><i>251.7</i></td> </tr> <tr> <td><i>Q(FIT indicator)</i></td> <td><i>0</i></td> <td><i>48.1</i></td> <td><i>137</i></td> <td><i>253</i></td> </tr> <tr> <td><i>Q(LI on LP-521-1)</i></td> <td><i>0</i></td> <td><i>48.2</i></td> <td><i>138</i></td> <td><i>254</i></td> </tr> <tr> <td><i>Q(display by CCS)</i></td> <td><i>0</i></td> <td><i>48.1</i></td> <td><i>136.2</i></td> <td><i>252.4</i></td> </tr> </table>				<i>H(measured)</i>	<i>0</i>	<i>5</i>	<i>10</i>	<i>15</i>	<i>Q(computed)</i>	<i>0</i>	<i>47.96</i>	<i>135.7</i>	<i>251.7</i>	<i>Q(FIT indicator)</i>	<i>0</i>	<i>48.1</i>	<i>137</i>	<i>253</i>	<i>Q(LI on LP-521-1)</i>	<i>0</i>	<i>48.2</i>	<i>138</i>	<i>254</i>	<i>Q(display by CCS)</i>	<i>0</i>	<i>48.1</i>	<i>136.2</i>	<i>252.4</i>
<i>H(measured)</i>	<i>0</i>	<i>5</i>	<i>10</i>	<i>15</i>																								
<i>Q(computed)</i>	<i>0</i>	<i>47.96</i>	<i>135.7</i>	<i>251.7</i>																								
<i>Q(FIT indicator)</i>	<i>0</i>	<i>48.1</i>	<i>137</i>	<i>253</i>																								
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<i>Q(display by CCS)</i>	<i>0</i>	<i>48.1</i>	<i>136.2</i>	<i>252.4</i>																								
Forms/Sheets Verified	By	Date	Loop Accepted By Owner																									
Loop Status Report	<i>J.D. Sewell</i>	<i>May-18-92</i>	By: <i>J.D. Smith</i>																									
Instrument Calibration Sheet	<i>J.D. Sewell</i>	<i>May-18-92</i>	Date: <i>Jun-6-92</i>																									
I&C Valve Calibration Sheet	<i>N.A.</i>																											
Performance Acceptance Test	By	Date																										
Performed	<i>J. Blow MPSDC Co.</i>	<i>Jun-6-92</i>																										
Witnessed	<i>B.deGlanville</i>	<i>Jun-6-92</i>	Loop No.: <i>30-12</i>																									

SECTION 44 44 73
ULTRAVIOLET DISINFECTION EQUIPMENT FOR WASTEWATER

EQUIPMENT AND COMPONENT NUMBER(S)

55-SCC-2200: System Control Center.
55-AE-1200: On-Line UV Transmittance Sensor.
55-HSC-1210: Channel 1 Hydraulic System Center.
55-PDC-1211: Channel 1 Power Distribution Center 1A-1C.
55-PDC-1212: Channel 1 Power Distribution Center 1D.
55-BNK-1001: Channel 1 UV Lamp Bank 1A.
55-BNK-1002: Channel 1 UV Lamp Bank 1B.
55-BNK-1003: Channel 1 UV Lamp Bank 1C.
55-BNK-1004: Channel 1 UV Lamp Bank 1D.
55-G-1250: Channel 1 Effluent Gate.
55-AE-1201A: Channel 1 UV Intensity Sensor Bank 1A.
55-AE-1201B: Channel 1 UV Intensity Sensor Bank 1B.
55-AE-1201C: Channel 1 UV Intensity Sensor Bank 1C.
55-AE-1202: Channel 1 UV Intensity Sensor Bank 1D.
55-LSL-1902: Channel 1 Low Level Sensor.
55-LT-1903: Channel 1 Level Indicator Transmitter.
55-FIT-1260A: Channel 1 Flow Indicator Transmitter A.
55-FIT-1260B: Channel 1 Flow Indicator Transmitter B.
55-HSC-2210: Channel 2 Hydraulic System Center.
55-PDC-2211: Channel 2 Power Distribution Center 1A-1C.
55-PDC-2212: Channel 2 Power Distribution Center 1D.
55-BNK-2001: Channel 2 UV Lamp Bank 1A.
55-BNK-2002: Channel 2 UV Lamp Bank 1B.
55-BNK-2003: Channel 2 UV Lamp Bank 1C.
55-BNK-2004: Channel 2 UV Lamp Bank 1D.
55-G-2250: Channel 2 Effluent Gate.
55-AE-2201A: Channel 2 UV Intensity Sensor Bank 1A.
55-AE-2201B: Channel 2 UV Intensity Sensor Bank 1B.
55-AE-2201C: Channel 2 UV Intensity Sensor Bank 1C.
55-AE-2202: Channel 2 UV Intensity Sensor Bank 1D.
55-LSL-2902: Channel 2 Low Level Sensor.
55-LT-2903: Channel 2 Level Indicator Transmitter.
55-FIT-2260A: Channel 2 Flow Indicator Transmitter A.
55-FIT-2260B: Channel 2 Flow Indicator Transmitter B.

SALMON CREEK TREATMENT PLANT
UV SYSTEM REPLACEMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Work of this section includes design, fabrication, factory testing, delivery, installation assistance, onsite services during construction and commissioning of two open-channel Ultraviolet (UV) Disinfection Systems, each equipped with inclined, low pressure high output (LPHO) lamps, complete and operable with all power, control equipment and accessories, including downward acting weir gates, necessary for an operating system that complies with Washington Department of Ecology requirements for UV disinfection. The system scope of supply is to be provided by UV System Supplier (UVSS) Trojan.
- B. The work includes installation of equipment into a new channel (Channel 2) as well as a retrofit in an existing UV channel (Channel 1), replacing a Trojan UV4000 system installed in 2009.
- C. Contractor shall be responsible for negotiating terms and conditions of the Trojan Technologies subcontract.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American National Standards Institute (ANSI).
 - 2. American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF): Standard Methods for the Examination of Water and Wastewater.
 - 3. American Water Works Association (AWWA): C561, Fabricated Stainless Steel Slide Gates.
 - 4. ASTM International (ASTM):
 - a. A193/A193M, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
 - c. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - d. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 5. Institute of Electrical and Electronics Engineers (IEEE): 519-2014, Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
 - 6. International Ultraviolet Association (IUVA): Uniform Protocol for Wastewater UV Validation Applications (IUVA Protocol).

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7. National Electrical Manufacturers Association (NEMA).
8. National Fire Protection Association (NFPA): 70, National Electric Code (NEC).
9. National Water Research Institute (NWRI) and Water Research Foundation (WRF): Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, 3rd Edition (2012 NWRI Guidelines).
10. UL: 508, UL Standards for Safety Industrial Control Equipment.
11. U.S. Environmental Protection Agency (USEPA): Final Ultraviolet Disinfection Guidance Manual (UVDGM), 2006.

1.03 SUBMITTALS

- A. Action Submittals: Owner has worked with Trojan (the UVSS), outside of this Contract to prepare a submittal. A copy of this submittal is provided and does not require additional Engineer approval under this Contract.
- B. Informational Submittals:
 1. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data, including routine maintenance requirements prior to plant startup.
 2. Special shipping, storage and protection, and handling instructions.
 3. Provide original licenses/agreements of all computer software used in the system.
 4. Contact information for UV lamp and ballast suppliers other than UVSS.
 5. Factory Testing Plan and Report.
 6. Certification of factory testing and equipment assembly prior to shipment.
 7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
 8. Training Lesson Plan.
 9. Field Testing Documentation:
 - a. Testing Plan.
 - b. Functional Testing Report.
 - c. Performance Testing Report.
 - d. Field Service Report.
 10. Build America, Buy America (BABA) ACT Final Certification Statement attached as supplement to Section 01 77 00, Closeout Procedures.

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1.04 QUALIFICATIONS

- A. UVSS will provide description of the service, support, and maintenance capabilities that will be available to Owner, including office locations, engineering, and technical personnel at these locations, and their qualifications and experience related to UV disinfection projects.
- B. UV System provided by UVSS will be validated system by a credible third party, with bioassay dose-based sizing algorithm. The validation test protocols will comply in accordance with the USEPA UVDGM, NWRI Guidelines, and/or IUVA Protocol.
- C. UVSS provided UV System will be commercially available and in practice in the United States.
- D. UVSS will have a minimum of 5 systems sized similar to the specified flow and disinfection capacity and performance levels, identified in this section.
- E. Applicator Qualifications: Minimum 5 years' experience in application of specified products.
- F. Regulatory Requirements for Coatings:
 - 1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
 - 2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint Manufacturer's instructions.
 - b. SSPC PA 10.
 - c. Federal, state, and local agencies having jurisdiction.

1.05 SYSTEM DESIGN CRITERIA

- A. UV Systems are located downstream of secondary clarifiers. Final effluent will be continuous flow with daily and seasonal variations throughout the year.
- B. The UV Facility will be located outside with ambient temperatures at the Project Site ranging from 20 degrees F to 105 degrees F; short-term temperature excursions outside of this range may occur. The UV systems must fit into an operating area of approximately 2,000 square feet, which includes two UV channels, the UV power distribution centers, and the UV hydraulic system center. The UV system control module, 480/480V, and dry transformers will be located in an indoor electrical room. Relative humidity ranges from 20 percent to 100 percent. Outdoor equipment is in a rainy

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environment and corrosion protection is a critical design requirement. All equipment shall be furnished by the Contractor, except for that listed for UVSS in the Scope.

- C. Provide a complete UV System for design criteria shown below:

Description	Design Criteria
Design peak flow, mgd	68.4
Design maximum monthly flow, mgd	35
Design average daily flow, mgd	27.4
Maximum Flow through One Channel, mgd	34.2
Number of UV Channels	2
Suspended Solids	Less than 30 mg/L
BOD5	Less than 30 mg/L
Hardness	108 mg/L
Fecal Coliform Bacteria	Less than 200 cfu/100 ml; 30-day average
	Less than 400 cfu/100 mL; weekly average
E. coli	Less than 126 cfu/100 ml; 30-day average
	Not to exceed 406 cfu/100 ml; single sample
UV Dose	Minimum 29.7 mJ/cm ²
UV Transmittance	55 Percent at 254 nm; fouled sleeves and at the end of lamp life
Effluent Temperature	Minimum 13°C; maximum 25°C
End-of-Lamp-Life Factor (EOLL)	0.8 (or third party certified technology-specific EOLL); maximum 0.9
Fouling Factor (FF)	0.8 (or third-party certified technology-specific FF); maximum 0.95

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- D. UV System Type: Open-channel type, inclined orientation.
- E. UV Trains/Channels:
 - 1. The UV system will consist of two trains. One train is a retrofit of an existing channel (Channel 1). The other UV train will be installed in a newly constructed channel (Channel 2).
 - 2. The UVSS shall be responsible for design and furnishing the above grade raised cover frames with cable service trays covering each channel to the limits shown on mechanical plan drawings for the routing of power cables and hydraulic hoses.
 - 3. UV trains/channels will be sized for ultimate build out and treat equal flow.
 - 4. UV channels will be constructed of concrete as shown on the Drawings.
 - 5. UV channels will include raised frame covers over in-channel UV equipment provided by UVSS.
 - 6. UV channels will be located outside. A canopy cover is provided over equipment panels.
- F. UV Equipment Arrangement (per channel): A minimum of four UV banks will be in series for any train/channel in operation.
- G. Scale Up: UV system will be designed in compliance with the scale-up limitations specified in the 2012 NWRI Guidelines.
- H. Design UV Dose: UV system will be designed to deliver a minimum UV dose indicated in the design criteria table at design peak flow and minimum UV transmittance at the end of lamp life after reduction of quartz sleeve fouling based on MS2 phage bioassay.
- I. End-of-Lamp-Life Factor (EOLL): The design UV dose will be based on the EOLL factor of 0.80 unless UVSS has a technology-specific EOLL factor certified by an independent third party. An EOLL factor higher than 0.90 will not be considered.
- J. Sleeve Fouling Factor (FF): Sleeve fouling causing attenuation of the minimum dose during operation. The design UV dose will be based on the fouling factor of 0.8 unless UVSS has technology-specific fouling factor certified by independent third party. A FF higher than 0.95 will not be considered for mechanical or mechanical/chemical wiping system.
- K. Redundancy: Redundancy is provided by one channel out of service sized for 50 percent of design peak flow.

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- L. UVSS in coordination with Contractor, will be responsible for establishing control of UV system and for interfacing with plant control system. PLC equipment, I/O equipment and control programming required to make a full and operating system will be provided.
- M. UV System Validation: Validation will provide minimum pathogen inactivation requirement over full range of flows, UV dose, and water characteristics at end of lamp life and under fouled quartz sleeve conditions. Validation testing shall be based on MS2 bacteriophage as an indicator organism.
- N. UV system will be programmed, consistent with USEPA UVDGM, such that UVT greater than maximum validated UVT will be considered equal to maximum validated UVT in system programming and dose calculations. No extrapolation of system performance will be allowed.
- O. Input Voltage:
 - 1. 480V ac, 60-Hz, three-phase, four-wire, plus GND for each Power Distribution Center.
 - 2. UV system will be capable of operating during a 10 percent PLUS or MINUS voltage swing, without shutting down.
 - 3. UV system will be capable of operating during an 8 millisecond voltage drop without shutting down.

1.06 SYSTEM WARRANTY

- A. UV system will be warranted to be free from defects in materials and workmanship, including damages from shipping, for a period of 12 months from date of final completion of construction Contract or 18 months after delivery, whichever comes first. Any equipment failing within warranty period will be repaired or replaced at no cost to Owner.
- B. UVSS will provide a written warranty of nominal lamp (minimum 12,000 hours; pro-rated after 9,000 hours), quartz sleeves (minimum 10 years; prorated after 1 year), and ballast life (Minimum 10 years; prorated after 1 year). If actual nominal lamp, sleeve, or ballast life is less than warranted, UVSS will replace defective lamps, sleeves, and ballasts at no cost to Owner.
- C. UVSS will provide a written warranty identifying that, if greater than 20 percent of lamps within the system require replacement prior to the nominal life warranted by UVSS, UVSS will replace all of the lamps in the UV System with new lamps at no cost to Owner. Full replacement of lamps does not apply, if the lamp failures can be shown to be a result of the system being operated outside the procedures indicated in UVSS O&M Manual.

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- D. UVSS will provide a written warranty identifying that, if greater than 20 percent of ballasts within the system require replacement prior to the nominal life warranted by UVSS, UVSS will replace all ballasts in the UV System with new ballasts at no cost to Owner. Full replacement of ballasts does not apply, if the ballast failures can be shown to be a result of the system being operated outside the procedures indicated in UVSS O&M Manual.
- E. UVSS will provide a written warranty identifying that, if greater than 20 percent of the quartz sleeves fail to maintain quartz integrity prior to nominal life warranted by UVSS, the UVSS will replace all quartz sleeves at no cost to Owner. Full replacement of quartz sleeves does not apply, if the failures can be shown to be a result of the system being operated outside the procedures indicated in UVSS O&M Manual.
- F. UVSS will provide a written warranty identifying that, if greater than 50 percent of sensors within the system require replacement prior to the nominal life warranted by UVSS, UVSS will replace all sensors in the UV System with new sensors at no cost to Owner. Full replacement of sensors does not apply, if the sensors failures can be shown to be a result of the system being operated outside the procedures indicated in UVSS O&M Manual.

1.07 PERFORMANCE GUARANTEE

- A. UV system provided will produce an effluent conforming to effluent standards defined in the design criteria of this specification. The performance will be guaranteed by the UVSS.
- B. UVSS will guarantee compliance with the following disinfection requirement for a period of 1 year from final completion, as identified in Section 01 31 15, Construction Sequencing and Constraints:
 - 1. 30-day average and weekly average sample of fecal coliform measured in the disinfected effluent does not exceed the design criteria.
- C. UVSS will guarantee compliance with the disinfection requirement provided that:
 - 1. Constructed facilities do not deviate substantially from UVSS design recommendations.
 - 2. Actual flow rates do not exceed peak flow given in design criteria table.
 - 3. Wastewater characteristics are no worse than values given in design criteria table.
 - 4. Owner operation and maintenance procedures do not deviate from UVSS's recommendations.

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- D. If UV System should fail to meet effluent disinfection requirements within the first year of operation after final acceptance, except for nonwarranted causes as noted, UVSS will provide services of an experienced factory-trained authorized representative to inspect and correct UV System deficiencies within 2 weeks of written notification of non-compliance with effluent disinfection requirements.
- E. If cause of failure is determined to be nonwarranted, Owner will reimburse UVSS for all reasonable costs of investigation, otherwise, UVSS will be solely responsible for costs to modify and retest the UV System to demonstrate compliance with effluent disinfection requirements.
- F. If correction of the failure requires provision of additional equipment, installation of additional equipment will be only as accepted by Owner. If the UV System fails to meet effluent disinfection requirements following correction(s), Owner may require the UV System to be removed within 30 days after rejection or replaced with a UV System able to meet effluent disinfection requirements at no cost to Owner. This includes all expenses of the Engineer, Owner, and Construction Manager associated with coordinating the replacement and modification of facilities.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Each item of equipment will be tagged or marked as identified in the delivery schedule or on the Shop Drawings prior to shipping. Complete packing lists and bills of material will be included with each shipment.
- B. Shipping:
 - 1. UVSS ships the entire UV System equipment simultaneously.
 - 2. Clearly identify packages as to Project, destination, and contents. Packaging will protect equipment from damage during shipping.
 - 3. Deliver equipment and appurtenances to designated location.
 - 4. Polish and protect surfaces from corrosion and damage during shipment, normal handling, and installation.
 - 5. Pack equipment for shipment and protect electrical equipment from moisture damage.
 - 6. Identify each component with durable labeling other than paper that is resistant to sunlight exposure and moisture.
 - 7. Coordinate shipping with Contractor.

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C. Delivery and Storage:

1. Provide written notice to Contractor and Owner a minimum three 3 calendar days prior to anticipated date of delivery to afford an opportunity to be present and inspect unloading of UV System equipment.
2. UVSS's authorized representative will be available for assistance upon delivery and will assist Contractor as follows:
 - a. Inspecting equipment upon arrival at Site to ensure equipment has been delivered in good order and that no damage has occurred during delivery.
 - b. Identification of and notification to Contractor and Engineer of discrepancies between shipping lists and equipment received.
3. A complete set of manufacturer's instructions covering storage, installation, operation, lubrication, and maintenance will be furnished no later than the date the equipment is shipped. Storage, installation, lubrication, and startup of the equipment and motors will be in strict conformance with the UVSS's instructions.
4. Grease and lubricating oil will be applied to all bearings and similar items.
5. All equipment will be delivered by the UVSS to the Site ready for installation. The Contractor will store the equipment as directed by the UVSS.
6. Deliver materials dry and undamaged.

- D. Damaged and/or missing UV System equipment will be replaced, by UVSS authorized technician, with new equipment at no additional cost to Owner: Replenish any spare parts used to specified quantity at no additional cost to Owner.

1.09 EXTRA MATERIALS

A. General:

1. Provide Spare Parts:
 - a. In the shipment along with the equipment to Site.
 - b. Identical with original installed parts.
 - c. In clearly identified and labeled containers with quantity, item description, and part number.
2. Provide any special tools required to facilitate maintenance of any component of the UV System.

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3. UVSS will furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
UV Lamps	20% of total lamps
Sleeves	10% of total sleeves
Ballasts	10% of total ballasts
UV Intensity Sensor	One
Cleaning System Wipers	20% of system
Cleaning Chemicals (if applicable for UV system)	6-month supply
Stem Collars per Gate	One
Bronze Lift Nuts per Gate	One
Weir Gate Electric Actuator	One
Special tools required to maintain or dismantle gate actuator	One complete set

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturer and its equipment model are acceptable:
1. Trojan; Signa. No “or-equal” or substitutions permitted.

2.02 GENERAL REQUIREMENTS

- A. Electrical assembly will meet requirements of NFPA 70 (NEC), NEMA, and applicable local electrical codes.
- B. Components, including equipment, coatings and other parts of UV System will comply with AWWA standards, unless specified otherwise.
- C. Operation Requirements: To minimize power consumption, the UV System will be capable of being operated based on actual conditions measured by in-line instruments such as UV transmittance, UV intensity sensor, flow meters, and channel water level measurement.

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2.03 UV SYSTEM

A. Materials of Construction:

1. All metal components considered submerged, contacted by liquid, or below the operating floor will be:
 - a. Welded Type 316L stainless steel, pickled, passivated, and bead-blasted for uniform external finish.
 - b. Where welding is required for stainless steel components; Type 316L-Grade (low carbon) stainless steel will be furnished.
 - c. Hardware, fasteners, anchor bolts, nuts, plates, and angles will be Type 316 stainless steel.
 - d. Nonmetallic materials will be suitable for continuous exposure to UV light.
 - e. Type 304 or Type 316 stainless steel will be used for cabinet enclosures.

B. All equipment provided under this specification will be new and will be the standard product of the UVSS.

C. Control panel will be affixed with a UL 508A label “Listed Enclosed Industrial Control Panel” prior to shipment to the Job Site. Control panel without an affixed UL 508A label will be rejected and sent back to the factory.

D. Harmonic frequency mitigation to meet IEEE 519.

E. UV Banks:

1. Each bank will be fully waterproofed, gasketed and capable of being hosed down from any direction for maintenance without any penetration of liquid or dust into the module interior.
2. Each bank will have lamps mounted inside watertight quartz sleeves. The UV lamps will be completely isolated from the wastewater flowing through the channel and will be able to be replaced while wastewater is flowing through the channel.
3. Each bank will be identified by electronic serial number accessible from the UV system control panel.

F. Ballasts:

1. Electronic ballast with multiple power settings ranging from at least 50 percent to 100 percent maximum power.
2. Each ballast will be designed to power a maximum of two UV lamps.

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3. Warranty:
 - a. Warranted for minimum 10 years.
 - b. If ballast fails within warranty period, provide replacement ballast with prorated price after 1 year: (10-warranty year times 10 percent) of original price.

G. UV Lamps:

1. Low Pressure High Output UV lamps with no less than 500 input watts per lamp including ballast losses.
2. Lamp Base:
 - a. Resistant to UV:
 - 1) Warranty: UV lamps will be warranted for minimum 12,000 hours of useful life and the lamp replacement cost will be pro-rated after 9,000 hours of use.

H. Quartz Sleeves:

1. Each quartz sleeve will be independently sealed within system.
2. Sleeves will have a minimum UV transmittance of 92 percent at 254 nm when clean and will not degrade with use, excluding fouling.
3. Guaranteed for a minimum duration of operation (in years). At end of guaranteed sleeve life, sleeve output will be greater than or equal to 92 percent of new sleeve output immediately after sleeve cleaning.
4. Materials: Type 214 Clear Fused Quartz, 99.9 percent silicon dioxide quartz. High purity, rated for maximum possible UV transmittance.
5. Warranty:
 - a. Warranted for minimum 10 years.
 - b. If sleeve fails within warranty period, provide replacement sleeve with prorated price after 1 year: (10-warranty year times 10 percent) of original price.

I. Automatic Cleaning System:

1. Automatically initiated and controlled cleaning cycle capable of cleaning lamp sleeves and UV sensor, with manual cleaning override.
2. The cleaning cycle will be manually or automatically initiated and controlled from the operator interface.
3. UV system will be fully operational, providing disinfection, during cleaning cycles.
4. Cleaning cycle intervals will be field adjustable within the range of once per hour to once per week.

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5. Wipers will be fabricated of UV resistant material and installed in a manner which accommodates any irregularities associated with the quartz sleeves and precludes any binding during operation.
6. The wipers will be replaceable without having to dismantle the wiper drive system or without disassembling the module structure.
7. The wipers will travel the full length of the UV lamp sleeves. Designs in which the wipers only travel part way along the sleeves will not be acceptable.
8. Module cleaning systems which rely on a centralized method (such as a compressor or hydraulic pump) for driving the wiper where the failure of the component would result in a loss of wiping capability in the entire system, will be equipped with a backup compressor or pump and associated automated valving.
9. All lamp sleeves will be able to be periodically cleaned out of channel manually without disassembly of UV module.
10. If chemical is provided with wiper system, provide a no or low phosphorus content version.

J. UV Intensity Sensor:

1. Provide at least one UV intensity sensor for each UV bank.
 - a. To continuously sense UV intensity produced with indication corresponding to 0 percent to 100 percent UV intensity.
 - b. Will measure only the germicidal portion of UV light at 253.7 nanometers.
 - c. Will not degrade after prolonged exposure to UV light.
 - d. Automatically cleaned at the same frequency as the UV lamps.

K. Water Level Sensor:

1. Provide one per channel.
2. Install downstream of UV System in each open channel.
3. Extinguish UV lamps automatically if water level in the channel drops below the preset low level.

L. Water Level Control:

1. Electrically-operated Downward Acting Weir Gate for each channel, Provided by UVSS:
 - a. Gate size, elevation, and travel distance to be determined by UVSS and designed to maintain a minimum and maximum channel water level as required to keep lamps submerged properly.

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- b. Coordinate with design engineer prior to fabrication and installation.
 - 2. Located downstream of UV banks in each channel.
- M. Lifting Mechanism:
 - 1. The UV System will include mechanisms to remove an entire bank from the UV channel.
 - 2. If hydraulic fluid is used for lifting mechanism, provide food grade hydraulic fluid.
- N. On-Line UV Transmittance Analyzer:
 - 1. Provide one optical absorption sensor for UV transmittance.
 - a. Manufacturer and Product:
 - 1) Endress + Hauser; Viomax CAS51D-2DL1/0 Model Number AAC2A8 Optical absorption sensor, UV-range digital sensor with the following features:
 - a) Application/Measuring Range: SAC, 0-250 1/m.
 - b) Optical Path Length: 8 mm.
 - c) Adaption Cable: Fixed cable; crimp sleeves.
 - d) Cable Length: 100-foot length.
 - b. No "or-equal."
- O. Flow Straightening Baffle Plate:
 - 1. Provide flow straightening baffle or baffles upstream of the UV modules in each channel as shown on the Drawings, complete with fasteners and anchoring.
 - 2. Baffle plate shall be Type 316 stainless steel, minimum 1/4-inch thick. Plate shall have 60 percent porosity, minimum, and be the full height and width of the channel.
- P. Raised Cover Frames:
 - 1. Provide above grade raised cover frames as shown on the Drawings, complete with fasteners and anchoring, for the staging and routing power cables and hydraulic hoses between system panels and UV banks and lamps.
 - 2. The raised cover frame design includes cable service trays and support frame over each channel, and sectional coverings with a minimum 6 inches from floor of raised cover frame to bottom of sectional coverings and maximum above grade finished height of 8 inches.

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3. Cover sections span across the cable service trays and channel supported by the cover frame system to facilitate maintenance of equipment.
4. The raised cover frame design shall include all structural support elements.
5. The covering shall be sectional with each section readily removed and replaced by two operators without disassembly of supports.
6. Cover sections shall set flush with the top of cover frame. The covers and frame shall be designed for a load of 100 psf.
7. The material of construction for support frame and cable service trays shall be Type 304 stainless steel or other non-corrosive material.
8. For weight and thickness considerations, the sectional coverings shall be constructed of FRP.
9. A minimum separation of 42 inches shall be maintained between raised cover frames to allow for cart access.

Q. Safety Equipment:

1. The UV System will include four face shields and four goggles that block UV energy between 200 nanometers to 400 nanometers.
2. The UV System will include two signs reading:
“WARNING-ULTRAVIOLET EQUIPMENT - USE EYE PROTECTION.”
 - a. All signage will be constructed of corrosion and UV resistance materials.
 - b. Signs will be mounted by Contractor at Owner-specified locations.

2.04 FABRICATED MOTORIZED WEIR GATES

- A. Conform to AWWA 561.
- B. Rising stem type.
- C. Downward acting weir gate type for water level control in each channel with invert seal per schedule at the end of this section.
- D. Material:
 1. Type 316/316L Stainless Steel:
 - a. Plate, Sheet, and Strip: ASTM A240/A240M.
 - b. Bars and Shapes: ASTM A276.
- E. Performance Requirements: Leakage shall not exceed 0.05 gallons per minute per foot of gate periphery under either seating or unseating head conditions.

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F. Guide Frames:

1. Stainless steel of one-piece design, with gussets provided to accommodate unseating head. Sandwich type and two-piece guide designs are not acceptable.
2. Vertical Guides: Design for maximum rigidity and extend in one continuous piece from gate invert to form posts for support of gate operators of self-contained gates.
 - a. Weight: Not less than 13 pounds per linear foot for wall-mounted frames, and not less than 6.5 pounds per linear foot for channel-mounted guides.
 - b. Incorporate a replaceable, self-adjusting, UV-stabilized UHMW polyethylene seal with nitrile compression cord. Seal shall be mechanically fastened in the guide slot on both the upstream to downstream sides of the gate disc. No wedges, pressure pads or similar wedging devices are allowed.
 - c. "J-bulb," "P-seals," "d-seals" or similar rubber seals are not acceptable.
3. Frame Invert: Furnish an EPDM insert to function as a seating surface for the gate disc.
 - a. Weight: Not less than 13 pounds per linear foot for wall-mounted frames, and not less than 6.5 pounds per linear foot for channel-mounted inverts.
4. Join vertical guide frames and invert with factory welded corners.
5. Size guided slot to provide a minimum disc engagement of 1 inch on each side.

G. Disc:

1. Disc Plate (Sliding Member): One-piece stainless steel plate. Reinforce as required so that disc will not deflect more than $1/720$ of gate span, or $1/16$ inch, whichever is less, when the upstream liquid depth (seating head side) is as shown on the Motorized Effluent Gate Schedule at the end of this section and downstream liquid depth is less than $1/2$ inch.
2. Reinforce gate disc with one-piece stainless steel angles or channels welded to the disc plate. Bolted reinforcements will not be permitted.
3. Portion of slide that engages the frame shall have a minimum thickness of $1/2$ inch.

H. Stems:

1. 1-1/2-inch minimum diameter, ASTM A276, Type 316L stainless steel.
2. Threads: Acme type with RMS surface roughness of 16 microinches or less on the flanks. Stub threads are not acceptable. Extend threaded

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portion of stem 2 inches above operator when gate is in CLOSED position.

3. Ratio of the unsupported stem length to the radius of gyration, both in inches, shall not exceed 200.
4. Stems to withstand in compression, without damage, the thrust equal to at least 2-1/2 times the rated output of the hoisting mechanism, with a 40-pound effort applied to the handwheel or crank.
5. Design electric motor-driven floor stands to withstand at least 1.25 times the output thrust of the motor in the stalled condition.
6. Adjustable stop collar for the CLOSED position.
7. Connect rising stems to the disc plate with a yoke, bolted to the stem and welded to the disc.

- I. Stem Guides: Type 316 stainless steel stem guides, mounted directly to frame and spaced so that L/r ratio of stem does not exceed 200.

2.05 GATE OPERATORS

A. General:

1. Components: Withstand a minimum of 250 percent of design torque or thrust at extreme operator positions without damage.
2. Mount at walkway level, 36 inches above floor, unless otherwise indicated or required.
3. Gear train and gate stem sections shall produce a self-locking drive train.
4. Lift Nuts: Internally threaded with cut or cold-rolled Acme threads corresponding to stem threading.
5. Roller Bearings: Ball-thrust or tapered above and below lift nut to support both opening and closing thrusts.
 - a. Grease lubrication fittings for bearings.
 - b. Input pinions with needle or ball bearings.

B. Electric Motor Operators, Modulating:

1. 28-inch-high stainless steel direct yoke-mounted, totally enclosed weatherproof electric drive unit, and a totally enclosed gear box that operates a two-piece, bronze stem nut, which lifts the gate stem.
2. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of gate.
3. Stem protection for rising stem gates.

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4. Actuator Operation—General:
 - a. Actuator gearing shall be totally enclosed in an oil filled gearcase.
 - b. The manual override handwheel must be mechanically independent of the motor drive, and any gearing shall be such as to permit emergency manual operation in a reasonable time.
 - c. Gate position indication.
 - d. Comply with latest version of AWWA C542. See exceptions in Paragraph 2.05.B.5.
 - e. Controls integral with actuator and fully equipped as specified in AWWA C542. See exceptions in Paragraph 2.05.B.5.
 - f. Nonintrusive Electronics: Local controls, diagnostics, and calibration, including limit and torque switch settings, shall be accomplished nonintrusively. Electronic gate position display with capability to show continuous torque output. See exceptions in Paragraph 2.05.B.5.
 - g. Each actuator must be factory performance tested.
 - h. Rated running torque equal to 20 percent of the motor starting torque at a rated running time of 15 minutes, without exceeding the allowable NEMA temperature rise for the insulation class used. See exceptions in Paragraph 2.05.B.5.
 - i. Modulating (M) Service Requirements:
 - 1) Size motors for continuous duty.
 - 2) Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain gate position.
 - 3) HAND/OFF/AUTO (LOCAL/OFF/REMOTE) selector switch, padlockable in each position:
 - a) Integral OPEN/STOP/CLOSE momentary pushbuttons with seal-in circuits to control gate in HAND (LOCAL) position.
 - b) 4 mA dc to 20 mA dc input signal to control gate in AUTO (REMOTE) position.
 - c) Auxiliary contact that closes in AUTO (REMOTE) position.
 - 4) OPEN and CLOSED indicating lights.
 - 5) AC motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour. See exceptions in Paragraph 2.05.B.5.
 - 6) Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.

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- 7) Gate position output converter that generates an isolated 4 mA dc to 20 mA dc signal in proportion to gate position, and is capable of driving into loads of up to 500 ohms at 24V dc.
- j. Actuator Power Supply:
 - 1) 480 volts, three-phase, unless otherwise indicated.
 - 2) Control power transformer, 120V or 24V dc secondary.
 - 3) Externally operable power disconnect switch.
 - 4) Electric circuit of the actuator shall not vary with the gate type, remaining identical regardless of whether the gate is to OPEN or CLOSE on torque or position limit.
- k. Enclosure:
 - 1) As defined in NEMA 250, Type 4, unless otherwise indicated.
 - 2) Allow for temporary site storage without the need for electrical supply connection, and without voiding the warranty.
 - 3) Contain 120-volt space heaters, if required to prevent condensation.
- l. Limit Switch:
 - 1) Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120V ac.
 - 2) Each gate actuator to have a minimum of two auxiliary transfer contacts at end position, one for gate FULL OPEN and one for gate FULL CLOSED.
 - 3) Housed in actuator control enclosure.
- m. Manufacturer:
 - 1) Rotork Controls.
 - 2) Harold Beck & Sons, Inc.
- 5. Exceptions for Permanent Magnet Motors:
 - a. For permanent magnet type motors, with equal start and run torque, no torque switches or thermal overload protection shall be required.
 - b. Such motors must be torque self-limiting and rated for continuous duty of 3,600 starts/hr. Torque sensing and monitoring must be provided.
 - c. Must meet or exceed performance criteria specified in AWWA C542 for three-phase electric, multi-turn actuators using induction motors,
 - d. Exceptions to Paragraphs 2.05 B.4.d, e, h and 2.05 B.5 shall apply.

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2.06 INSTRUMENTATION AND CONTROL

A. Control Panel:

1. Material: Stainless steel.
2. NEMA Rating: 4X.
3. Panel will be Supplied with a Single Power Feed: 120V ac UPS power circuit.
4. Wall mounted, front access.
5. Provide the panel complete with programmable logic controller (PLC), 24V dc power supplies, Ethernet Switch, uninterruptible power supply (UPS), and operator controls and interfaces including operator interface terminal (OIT).
6. Power supply to the UV System main control panel will be 120V, single-phase, 60-Hz.

B. Provide PLC monitoring of all UPS units. As a minimum, monitor UPS status and common alarm conditions provided by the UPS manufacturer.

C. External Interface via Ethernet/IP:

1. All communication with the Owner's Plant Control System will be via the Ethernet network connection. Software addresses for interface with the Plant Control System will be coordinated through the submittal process.
2. Provide all control, monitoring, trending, and alarm signals to the Owner's Plant Control System to support replication of OIT screens at the Owner's HMI, including system control and operator adjustment of setpoints. Data will be organized within contiguous memory blocks in the PLC to simplify coordination and interface with the Owner's Plant Control System.
 - a. Special Requirements: Provide heartbeat for PLC/communications failure detection to the Owner's Plant Control System. Coordinate with the Owner.
3. The UV control system will be capable of controlling UV banks based on the flow measured upstream of the UV system, intensity measurements and transmittance measurements. The control panel will provide complete operator interface through a display screen.
4. UVSS will provide UV System controls with the following characteristics:
 - a. Operator Adjustable Lamp Status: MANUAL, OFF, or AUTO.
 - b. Cycle each bank for equal wear and time off to minimize bank cycling.

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5. Information displayed as minimum when prompted:
 - a. Module identification.
 - b. UV intensity.
 - c. UV transmittance.
 - d. Lamp hours.
 - e. Cycles.
 - f. Communication link status.
 - g. Backup battery condition.

D. Coordination with Plant Control System Integrator:

1. The System Integrator will assign tag numbers for alarms and status.
2. Coordinate and finalize data exchange requirements with System Integrator.

2.07 ELECTRICAL

A. Electrical components, wiring, and controls on or within the UV System as a whole will be designed, constructed and supplied by the UVSS and in accordance with the current edition of the National Electrical Code and all applicable state and local electrical codes.

B. Power Distribution Center (PDC):

1. Material: Stainless steel.
2. NEMA Rating: 4X.
3. PDCs will be provided for one to three banks (as required) to power the components in each channel such as lamp ballasts, wipers, instrumentation, etc.
4. An isolation transformer for each PDC (supplied by others outside of UVSS scope of supply) will be provided to supply the correct voltage required by the equipment.
5. Panel will be located at the Ultraviolet Disinfection Facility. Panel maximum size will be 7 feet in height, 6 feet 1 inch in width, and 2 feet 3 inches deep. The width dimension includes AC unit and sunshade.
6. Each PDC shall be mounted on elevated supports of heights coordinated with the raised cover frame.
7. Data concentration will be through integrated circuit boards located inside the PDCs. Circuit breakers, ground fault circuit interrupters (GFCI), or fuses, if applicable, will be located inside the PDC and be capable of being reset/replaced and tested locally at the PDC. Visual confirmation of a tripped breaker, GFCI, or blown fuse will be provided.

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8. Wiring inside the PDC shall be properly isolated for proper ventilation and to prevent damage to the wiring.
9. Each module in the vertical system shall be isolated via two rectifier cards that each feed a ballast rack.

C. General Wiring and Termination Requirements:

1. Each rack/module shall be field serviceable while located in the channel and shall be fitted with separate water-resistant UL rated multipin connectors for power and data. Integral or chain-connected waterproof caps will be provided for each multipin connector.
2. Power interconnect cables and data cables provided in between the racks/modules and the PDC will be field terminated and interconnections shall be made by the Contractor.
3. CAT 6 data cable shall be supplied by the Contractor.
4. Cable tray, conductors, and/or trenches for power and data cables shall be provided by the Contractor. The Supplier shall provide conductor size and quantities to coordinate design and installation requirements with the Contractor.
5. Each module shall plug into a PDC via a multi-conductor cable and molded connector provided by Supplier.
6. Electrical power terminals shall be rated for 75 degrees C conductors.

D. Transient Voltage Surge Suppression:

1. In general, protect all elements of the control panel against damage due to electrical transients. Include grounding wire, stud, or terminal.
2. All panels and enclosures shall have a separate isolated copper ground bus for signal and shield ground connections. This isolated ground shall be bonded to a common ground point in accordance with the applicable local codes and standards.

2.08 ACCESSORIES

- A. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate will bear 3/8-inch-high engraved block type black enamel filled equipment identification number and letters indicated in this specification and as shown on the Drawings.
- B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.
- C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

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2.09 SOURCE QUALITY CONTROL

A. General:

1. Do not ship UV System until factory test report is approved by Engineer and Owner.
2. Factory test major components of UV System for compliance with specified requirements during a single test session.
3. Factory test will demonstrate that each individual UV System operates as specified.
4. Arrange for one or more factory tests to confirm demonstration of communication with plant PLC and acceptance of OIT by Owner.
5. Components will be fully assembled and hydrotested at factory prior to shipment.

B. Factory Test Plan and Report:

1. Develop and submit test plan. Plan will include, but not limited to:
 - a. Daily test schedule for duration of test.
 - b. Delivery of UV dosage.
 - c. Lamps.
 - d. Intensity sensors.
 - e. Cleaning system.
 - f. Motorized weir gates.
 - g. Control power panel for each system.
 - h. Instrumentation and controls for each system.
 - i. Operator interface units.
2. Upon conclusion of test, submit test report documenting tests performed, items witnessed, and results.

C. Factory Test: Demonstrate each component operates as specified.

D. Quality Control:

1. During factory testing the UV system is to be UL tested, approved, and stickered prior to shipment.
2. Owner, at their discretion may witness UV System equipment assembling and factory testing at the UV manufacturer's fabrication facility prior to shipment to Site. UVSS will coordinate equipment assembly and factory testing with Owner and provide a minimum 3 weeks' advanced notification of all activities. Owner will pay all travel costs associated with witnessing equipment assembly or testing.

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- E. Following shipment, UVSS will provide written certification that the UV System has been factory tested to comply with the specifications herein and has been properly assembled prior to shipment.

PART 3 EXECUTION

3.01 FABRICATION

- A. The UV Disinfection System specified herein shall be factory assembled, to the largest extent possible, complete with all components specified.

3.02 FACTORY TESTING

- A. Provide 4 weeks' notice to Engineer prior to commencing testing so that Owner and Engineer can witness testing at their own expense if desired.
- B. All system components of the UV Disinfection System shall be factory tested for compliance with the construction and functional requirements specified herein, and a certification of the results of these tests shall be submitted in writing to the Engineer for each module and control panel separately, prior to shipment.

3.03 INSTALLATION

- A. Installation of the UV equipment will be in accordance with the Contract Documents, and the UVSS's Engineering Drawings and instructions. Install all items as shown on the Drawings.

3.04 STARTUP

- A. The Contractor will furnish labor, material, equipment, and services required to conduct and satisfactorily complete startup, exclusive of the supplies provided by the UVSS.
- B. The UVSS will supervise the functional testing and provide startup assistance, to operate all support systems provided by or required by the UVSS for operation of the UV System.
- C. The UVSS will furnish all necessary supplies (excluding power) needed for the initial startup and testing of the equipment.
- D. The UVSS will establish, verify, and assist the Contractor in demonstrating proper operation of the UV System during startup.
 - 1. Check proper installation of the equipment.
 - 2. Provide proper inspection, checking, and adjustment of the equipment.

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3. Startup and field-testing for proper operation.
4. Provide assistance with Functional Testing on equipment in accordance with this section.
5. Provide assistance with Performance Testing on equipment in accordance with this section.

3.05 TESTING

A. General:

1. The following tests will be completed before the date of substantial completion:
 - a. Functional Testing.
 - b. Performance Testing.
2. The Contractor will supply all manpower and equipment, exclusive of the supervision of the UVSS, necessary to conduct and complete the testing.
3. The Contractor will be responsible for operation and maintenance of the UV System equipment, at the direction of the UVSS, until compliance with all disinfection requirements has been demonstrated.
4. The UVSS will provide a Testing Plan, including procedure and schedule, to Owner for review and approval before scheduling and performing any tests.
5. Sampling and testing procedure will comply with NWRI Guidelines.
6. Owner may conduct additional sampling and testing at any time at Owner's expense without providing advance notification to the UVSS.
7. Testing will be conducted at a time selected by the Contractor and mutually agreed to by the UVSS and Owner/Engineer.

B. Functional Testing:

1. Functional Testing is to demonstrate that the UV System and related control system operates in accordance with the specifications, including all operating, monitoring, and control functions.
2. Functional Testing will be conducted after installation, but prior to the Performance Testing.
3. Functional Testing will be conducted with Plant Water or Secondary Effluent that is pumped to the operational UV channel prior to discharge.
4. The Contractor, with assistance from the UVSS's representative, will conduct Functional Testing.
5. Functional Testing will be conducted on each individual component item until it has achieved one continuous hour of satisfactory operation.

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6. The Functional Testing will be conducted in channel with flow to include, but not be limited to:
 - a. Wiring continuity test.
 - b. Control system loop test.
 - c. UV intensity sensor test to determine sensor-to-sensor variability, impact of sensor position and sensor accuracy. All on-line sensors will be tested.
 - d. Wiping system test.
 - e. Water level control functional test.
 - f. Monitoring instrument calibration.
 - g. Control Functions Test.
 - h. Alarm Function Test.
 - i. Harmonics test, measured at the input terminals to each PDC.
7. The Functional Test will include confirming the operability of the serial interface between the UV control panels, PLC, and the plant control system. Both the UVSS and Contractor will be present during the interface test.
8. Functional Testing will be witnessed by Owner/Engineer.

C. Performance Testing:

1. Performance Testing is to demonstrate that the UV System can achieve specified disinfection requirements and meeting the head loss requirements without exceeding the maximum power usage as stated in the UVSS's proposal.
2. Performance Testing will be conducted based on actual conditions for flow, UV transmittance, and dose as specified, and adjusted for degradation such as equipment aging and wear, fouling and cleaning efficiency.
3. Performance testing will be conducted for a minimum of 14 consecutive days.
4. The UVSS will provide detailed testing protocol for Owner's review and approval prior to the testing. The testing protocol will follow the NWRI guidelines, including, but not limited to the following:
5. Testing Flow Conditions: Peak design flow and average flow based on a flow rate per lamp basis.
 - a. Testing will be conducted on each individual bank.
 - b. Testing will be conducted on each channel under design peak flow and average flow conditions with the control system in automatic settings.
 - c. Each test will take place over a minimum 2-hour period with samples collected during the period at approximately half hour increments following the start of each test.

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- d. Samples for fecal coliform and E. Coli will be collected on the system influent and effluent for each test.
 - e. Sample analysis will be in accordance with the procedures described in the latest edition of “Standard Methods for the Examination of Water and Wastewater.”
6. The Contractor and Owner will operate the facility such that specified flow conditions are approximately simulated to the UV channel. All reasonable efforts will be made to approximate steady-state flow conditions for the duration required to allow samples to be taken.
7. Testing will be conducted after the lamps have completed a 100-hour burn-in period.
8. The lamps will be automatically cleaned at the rate of 48 cycles per day per lamp (maximum) for the duration of the test. Manual cleaning of any kind by the UVSS will not be allowed during the testing period.
9. Sample collection will be done by the Contractor and Owner’s laboratory personnel. The sample collection will be directed by the UVSS representative.
10. Sample analysis will be conducted at Owner’s laboratory and at Owner’s expense.
11. The Contractor will coordinate with laboratory personnel to collect, preserve, and transport the samples to the laboratory; conduct the required analyses, and report the results. Chain of custody procedures will be followed using a custody form typically used by Owner.
12. All testing results will meet the disinfection requirements described in this section.
13. The data to be determined from each test will include, but is not limited to, the following:
 - a. Flow rate.
 - b. Detention time based on volume of water flowing by the UV lamps.
 - c. Number of lamps in operation.
 - d. UV dose.
 - e. Fecal coliform and E. Coli counts in system influent and effluent.
 - f. Total suspended solids.
 - g. 5-day Biochemical Oxygen Demand.
 - h. UV transmittance.
 - i. UV intensity reading from the online instrumentation.
 - j. Water level(s) under various flow conditions.
 - k. Wiping frequency.
 - l. Power Consumption: Amps, kW demand, and kWh operating of the UV System and ancillary equipment.

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14. Influent characterization will be conducted on the first day of the testing period. The following data will be collected on the UV System influent sample for the characterization:
 - a. pH.
 - b. Hardness.
 - c. Calcium.
 - d. Total dissolved solids (TDS).
 - e. Total and dissolved iron.
 - f. Temperature.

D. Test Reports:

1. The UVSS representative will prepare the Functional Testing Report and the Performance Testing Report based on the test results.
2. For each report, one electronic copy will be submitted to the Engineer.
3. Owner will provide sampling data paperwork to the UVSS, for inclusion in the report, from any portion of the analysis conducted by Owner.
4. Report will include the following information when applicable to either Functional Testing or Performance Testing:
 - a. Date and time of inspection, sampling, or testing.
 - b. Flow condition during testing.
 - c. Record of conditions at the plant noting any unusual circumstances.
 - d. Plans and description of locations of samples taken and testing performed.
 - e. Lamp status.
 - f. Ballast status.
 - g. Laboratory reports including:
 - 1) Signature of the person performing tests.
 - 2) Standard method and analytical method for conducting the test.
 - 3) Chain of custody sheets.
 - 4) Testing results.
 - h. Interpretation of results.
 - i. Recommended corrective actions to bring equipment into compliance, if required.
5. Pass/Fail Criteria of Microbial Inactivation Testing: UV system will be considered passing if the arithmetic average of all 30 samples is equal to less than half of the 30-day average permit limit of 200 cfu per 100 mL or 100 cfu per 100 mL fecal coliform and 126 cfu/100mL or 63 cfu/100mL E. Coli.

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6. Submit test reports to Owner within 2 weeks of test completion for review and acceptance.
7. Performance Testing will not be conducted prior to the acceptance of the Functional Testing Report.

3.06 FIELD QUALITY CONTROL

A. General:

1. UVSS will complete Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services, upon satisfactory installation of UV System.
2. UVSS will calibrate instruments, sensors, and meters supplied for testing, including UVT analyzers, UV intensity sensors, and power consumption meters.

B. Definitions of UV System/Component Failure:

1. UV system will be deemed to have failed when minimum required RED, as specified herein, cannot be achieved under conditions that include flow, UVT, and lamp and sleeve life within design values.
2. If the UV System and ancillary equipment fail to meet Performance Requirements specified herein, modifications to equipment or operational changes will be made to produce an installation which will satisfy the requirements:
 - a. Owner will notify UVSS, and UVSS will investigate the problem and develop a corrective plan within 2 weeks of notification.
 - b. After modifications, the equipment will be completely re-tested as specified in this section. Additional testing will have the same requirements and duration as initial testing specified.
 - c. UVSS will be solely responsible for costs for modifications to the UV System. This includes payments of all structural or electrical modifications necessary to accommodate the modified equipment.
 - d. UVSS will be solely responsible for costs for re-testing required to demonstrate compliance. This includes all engineering fees and expenses associated with Owner's and Engineer's witness of the re-tests.
3. Additional testing periods beyond the initial periods will not be a basis for extension of Contract Time or claims for additional compensation from Owner.

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4. If the UV System and ancillary equipment fail to meet Performance Requirements specified herein, and after several attempts of implementing the correcting measures by the UVSS, it will be Owner's option to require any or all, of the following:
 - a. Complete removal of the UV System and all associated equipment within 30 days after rejection.
 - b. Replacement with equipment able to meet Performance Requirements specified in this section at no additional cost to Owner.
 - c. The Contractor will provide continuous disinfection at all times.

3.07 MANUFACTURERS' FIELD SERVICES

A. See Section 01 43 33, Manufacturers' Field Services.

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
 - a. 1 person-day for initial onsite inspection and certification of shipment unloading.
 - b. 6 person-days in two trips (3 days for each channel) for installation assistance and inspection.
 - c. 16 person-days in four trips (4 days for each channel) for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation and post-startup training.
 - d. Contractor shall coordinate manufacturer presence at start of each test period.

B. Training General:

1. Training will not commence until accepted detailed lesson plan for each training activity has been reviewed by Owner.
 - a. The UVSS will submit a Training Lesson Plan to Owner 21 days prior to conducting the training. Training aids and hands-on demonstrations shall be described in the Training Lesson Plan.
2. Provide for training of designated Owner's personnel in operation and maintenance of UV system.
3. Training will consist of both classroom and hands-on sessions conducted at time and location acceptable to Owner.
4. Designate a person responsible for scheduling and coordinating training.

C. The UVSS will maintain records of the individuals that have completed training and provide information required for the documentation of training hours required for Owner's personnel.

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- D. Instructions will be specific to the models of equipment provided and will include both classroom and hands-on instruction.
- E. Provide separate training focused on topics for Owners operations and maintenance staff. A minimum of two sessions for each training topic will be conducted to allow for multiple shifts of Owner's personnel to receive the same training.
- F. Training will include as minimum:
 - 1. UV disinfection theory.
 - 2. System operations philosophy.
 - 3. The UV System overview.
 - 4. Processes training including start up, shut down, flow pacing or dose pacing.
 - 5. System Control:
 - a. Loop Functions: Understanding loop functions, including interlocks.
 - b. Loop Operation: For example, adjusting process variable setpoints, and control, and annunciator acknowledgment and resetting.
 - c. Interfaces with other loops and subsystems.
 - d. Calibration procedures for UVT analyzer, intensity sensors versus reference sensor.
 - 6. Routine and nonroutine maintenance training including lamp replacement, ballast replacement, intensity meter replacement and wiper replacement.
 - 7. Safety training including safety procedures for operation and maintenance.
 - 8. Mechanical equipment training.
 - 9. Electrical control training.
 - 10. Process logic control equipment training.
 - 11. OIT system training.
 - 12. Operator interface/system setpoints.
 - 13. Component performance requirements.
 - 14. Component functions.
 - 15. Component maintenance.
 - 16. Component troubleshooting.
 - 17. Instrument operation, maintenance, troubleshooting, replacement, and calibration procedures including but not limited to switches, meters and transmitters, and analyzers.
- G. Training sessions will be recorded as specified in Section 01 43 33, Manufacturers' Field Services.

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- H. The UVSS will be responsible for all costs associated with training and will provide required materials, texts, and supplies.
- I. All training materials will be provided by UVSS in written and electronic format. All training materials will be based on the O&M Manual.
- J. Coordinate training periods with Owner's operating personnel and manufacturer's representatives, and with submittal of O&M Manuals.
 - 1. Initial training will be completed at least 7 days prior to startup, but not more than 14 days prior to startup.
 - 2. Operation and Maintenance Manuals will be reviewed, accepted, and resubmitted in accordance with this section before start of training. Modifications resulting from startup of facility will be incorporated into final manuals.
 - 3. Initial training will be completed prior to commencement of Functional Testing.

3.08 SUPPLEMENTS

- A. The supplement listed below, following "End of Section," is a part of this specification:
 - 1. Motorized Effluent Gate Schedule.
- B. The supplement listed below, contained in Volume V, is a part of this specification:
 - 1. Volume V Pre-Selected Equipment Quote and Submittals Trojan Technologies/Section 44 44 73, Ultraviolet Disinfection Equipment for Wastewater, in its entirety.

END OF SECTION

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Motorized Effluent Gate Schedule							
Gate Identification No. and Location	Assembly Style	Frame Type¹	Wall Opening (width inches)	Gate Height (inches)	Flow Stream	Design Operating Head (feet) Seating/Unseating Condition	Operator Type/ Control Style
55G1250 - Channel 1 Effluent Gate ³	Downward acting weir gate for upstream level control ²	Channel Mounted (north side and floor)/ Face Mounted (south)	65	42	PLE	2.5 feet seating/unseating	Operator Type 4 ⁴ Electric Modulating with Remote Hand Station
55G2250 - Channel 2 Effluent Gate ³	Downward acting weir gate for upstream level control ²	Embedded side and floor mounting	65	42	PLE	2.5 feet seating/unseating	Operator Type 4 ⁴ Electric Modulating with Remote Hand Station
Notes: 1. See the Drawings for configuration and invert elevations. 2. Self-contained gate. 3. Provide splice in frame as required to allow for slide/seal removal/replacement. Provide frame reinforcing and bracing to concrete floor as required to accommodate splice. Provide structural calculations for frame. 4. See Section 35 20 16 2.05, Fabricated Slide Gates and Stop Logs, for gate operator description.							

