CITY OF PACIFICA, CALIFORNIA

UV DISINFECTION SYSTEM REPLACEMENT

CLIENT PROJECT NO. P034

TECHNICAL SPECIFICATIONS
DIVISIONS 03 - 41

BID SET

VOLUME 2 OF 5

MARCH 2024

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CITY OF PACIFICA

UV DISINFECTION SYSTEM REPLACEMENT

TABLE OF CONTENTS

VOLUME 1 OF 5

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

DIVISION 01 - GENERAL REQUIREMENTS

VOLUME 3 OF 5

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

VOLUME 4 OF 5

DRAWINGS

VOLUME 5 OF 5

APPENDICES

SECTION 03_01_02

CONCRETE REPAIR MORTAR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete repair mortar.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. T277 - Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

B. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or Cube Specimens).
   2. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

1.03 SUBMITTALS

A. Product Data.

B. Manufacturer's Instructions.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle packaged materials in the manufacturer's original, sealed containers.

B. Clearly identify each container with the manufacturer's name, name and type of product, and batch numbers.
   1. Remove damaged material from the site.

C. Store and condition the specified product as recommended by the manufacturer.

D. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground and suitably protected.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following or equal:
   1. Sika, SikaTop 123 Plus.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General: Composed of pre-packaged polymer-modified portland cement mortar used to perform shallow repairs on horizontal, vertical, and overhead applications.

B. Design requirements:
   1. Provide material suitable for performing in environments subject to corrosive attack by chlorides and sulfates, freeze/thaw cycles, low permeability, and abrasion resistant.
   2. Capable of being poured in place or troweled in place to suit the conditions encountered.

2.03 MATERIALS

A. Water: Potable, clean, and not detrimental to mortar.

2.04 MANUFACTURED UNITS

A. Component A shall be a liquid polymer emulsion with an acrylic copolymer base and additives:
   1. pH: 4.5 to 6.5.
   2. Film forming temperature: 73-degree Fahrenheit maximum.
   3. Tear strength: 950 pounds per square inch minimum.
   4. Elongation at break: 500 percent minimum.
   5. Particle size: Less than 0.1 micron.

B. Component A shall contain an organic, penetrating corrosion inhibitor that has been independently proven to reduce corrosion in concrete.
   1. The corrosion inhibitor shall not be calcium nitrite, and shall have a minimum of 5 years of independent field-testing to document performance on actual construction projects.

C. Component B shall be a blend of selected portland cements, specially graded aggregates, admixtures for controlling setting time, water reducers for workability, and an organic accelerator.

D. Materials shall be supplied as a factory-blended unit.

E. Placeable in 1/8 inch to 1-1/2 inch depth per lift for vertical applications and 1/8 inch to 1 inch in depth for overhead applications.

F. Typical properties of the mixed concrete repair mortar:
   1. Working time: Approximately 10 to 15 minutes.

2. Finishing time: 20 to 60 minutes.
3. Color: Concrete gray.

G. Properties of the cured concrete repair mortar:
1. Compressive strength: In accordance with ASTM C109 modified:
a. 1 day: 3,500 pounds per square inch minimum.
b. 7 days: 6,000 pounds per square inch minimum.
c. 28 days: 7,000 pounds per square inch minimum.
2. Flexural strength: 2,000 pounds per square inch at 28 days in accordance with ASTM C293.
3. Splitting tensile strength: 900 pounds per square inch at 28 days in accordance with ASTM C496.
4. Bond strength: 2,200 pounds per square inch at 28 days in accordance with ASTM C882 modified.
5. Permeability: 500 coulombs in accordance with AASHTO T 277.
6. Wet mix density: Approximately 132 pounds per cubic feet.
7. Shall not produce a vapor barrier.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mix in accordance with manufacturer's instructions.

B. At the time of application, substrate shall be saturated surface dry with no standing water.

C. Install in accordance with manufacturer's installation instructions.

D. Apply only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing:
1. Do not allow to dry out during placement.
2. Use water misting when required to prevent material from drying out before curing is started.

E. Moist cure with wet burlap or a fine mist for 7 days.

F. During the curing process, protect from rain, wind, or freezing as required. Keep sufficient covering on hand at all times for protection.

END OF SECTION

SECTION 03_01_04

STRUCTURAL CONCRETE REPAIR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Repairing damaged structural concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or Cube Specimens).
   2. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).
   3. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars).
   4. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   5. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

1.03 SUBMITTALS

A. Product data: Submit manufacturer's data completely describing structural repair concrete materials.

B. Certificates of Compliance.

C. Manufacturer's instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: The manufacturer of the specified product shall have been in existence for a minimum of 10 years.

B. Allowable tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.

B. Store and condition the specified product as recommended by the manufacturer.

C. Deliver, store, and handle packaged materials in the manufacturer's original, sealed containers, each clearly identified with the manufacturer's name, and name and type of product.

D. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground, and suitably protected.

1.06 PROJECT CONDITIONS

A. Existing conditions:
   1. Hot weather: ACI 305.
   2. Cold weather: ACI 306.
   3. Do not place concrete repair mortar during precipitation, unless adequate protection is provided.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Structural repair concrete composed of cementitious material capable of being placed in formed vertical and overhead applications, and on horizontal surfaces.

B. Design requirements:
   1. Provide material suitable for performing in environments subject to corrosive attack by chlorides and sulfates, freeze/thaw cycles, low permeability, and abrasion resistant.
   2. Provide concrete repair mortar cement that is placeable from 1 inch in depth and extendable in greater depths.
   3. Concrete repair mortar shall be capable of being poured in place or troweled in place to suit the conditions encountered.

2.02 MATERIALS

A. Structural repair concrete:
   1. Manufacturers: One of the following or equal:
      a. Master Builder Solutions/Sika, MasterEmaco S 466CI.
      b. Sika Corp., SikaTop 123 Plus.
   2. Compressive strength: As follows in accordance with ASTM C109:
      a. 1 day: 2,500 pounds per square inch, minimum.
      b. 7 day: 6,000 pounds per square inch, minimum.
      c. 28 day: 7,000 pounds per square inch, minimum.
   3. Bond strength by slant shear: 2,200 pounds per square inch minimum at 28 days, in accordance with ASTM C882 modified.
   4. Flexural strength: 2,000 pounds per square inch minimum at 28 days, when tested in accordance with ASTM C293, or 770 pounds per square inch minimum at 28 days when tested in accordance with ASTM C348.
   5. Rapid freeze/thaw durability: In accordance with ASTM C666; Procedure A.
      a. Relative durability factor at 300 cycles: 95 percent minimum.

6. Working time: 30 to 40 minutes.
7. Color: Concrete gray.

B. Water: Potable, clean, not detrimental to concrete.

C. Form materials:
   1. Smooth finish.
   2. Brace as required to maintain tolerances.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that concrete surfaces and exposed reinforcing are clean and free of contaminants.

3.02 PREPARATION

A. Prepare existing concrete by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

B. Thoroughly clean reinforcement and other embedded items to remove loose rust and other objectionable matter.

C. Thoroughly wet wood forms, except coated plywood, and adjacent concrete at least 1 hour in advance of placing concrete; securely close cleanout end inspection ports; repeat wetting as necessary to keep forms damp.

D. Damaged concrete:
   1. Areas to be repaired shall be clean, sound, and free of contaminants.
      a. Remove loose and deteriorated concrete by mechanical means acceptable to the Engineer.
      b. Saw cut perimeter 1/2-inch maximum.
   2. Chip concrete substrate to obtain a surface profile of 1/16 inch to 1/8 inch in depth with a new fractured aggregate surface.
      a. Area to be repaired shall be not less than 1 inch in depth.
   3. Concrete removal shall extend along the reinforcing steel to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.

E. Use the following procedures where reinforcing steel with active corrosion is encountered:
   1. Sandblast reinforcing steel to remove contaminants and rust.
   2. Determine section loss, splice new reinforcing steel where there is more than 15 percent loss as directed by the Engineer.
      a. If more than half the diameter of the reinforcing steel is exposed, chip out behind the reinforcing steel a minimum of 1/2 inch. Distance chipped behind the reinforcing steel must also equal or exceed the minimum placement depth of the accepted material.

F. Treat cracks in the substrate at the area of patching or overlay work as directed by the Engineer.

G. Extend existing control and expansion joints through any concrete repair.

H. Apply an epoxy-bonding agent to area to be repaired, as specified in Section 03_63_01 - Epoxies, prior to patching concrete with polymer-modified Portland cement mortar.

3.03 MIXING

A. Mix in accordance with manufacturer's mixing instructions.

3.04 INSTALLATION

A. Formed surface finishes:
   1. Smooth finish:
      a. Obtain by the use of plywood, sheet metal, or lined wood forms; no fins, pockmarks, or other irregularities shall be present in the exposed surfaces of concrete.
      b. Place no structural repair concrete without prior authorization of the Engineer.

B. Verify that form materials are in place and ready to receive installation of concrete repair material.

C. Install in accordance with manufacturer's installation instructions.

D. In accordance with ACI recommendations, apply concrete repair material only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing.

E. Scrub mortar into substrate, filling cracks, voids, and pores.

F. For new construction, finish of repaired area shall match required finish for concrete being repaired.

G. For existing concrete, finish of repair area shall match finish of concrete being repaired.

H. During the curing process, protect concrete repair from rain, wind, or freezing as required:
   1. Keep sufficient covering on hand at all times for protection of repair concrete.

3.05 CLEANING

A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03_11_07

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete formwork.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

B. Underwriters Laboratories (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Green Concrete: Concrete with less than 100 percent of the minimum specified compressive strength (f'_c).

1.04 SUBMITTALS

A. Information on proposed forming system:
   1. Submit in such detail as the Engineer may require assuring themselves that intent of the Specifications can be complied with by use of proposed system.
   2. Alternate combinations of plywood thickness and stud spacing may be submitted.

B. Form release agent.

1.05 QUALITY ASSURANCE

A. Qualifications of formwork manufacturers: Use only forming systems by manufacturers having a minimum of 5 years of experience, except as otherwise specified, or accepted in writing by the Engineer.

B. Regulatory requirements: Install work of this Section in accordance with local, state, and federal regulations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design of concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.
   2. Design forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.

B. Performance requirements:
   1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
   3. Provide sufficient number of forms so that the work may be performed rapidly and present uniform appearance in form patterns and finish.
   4. Use forms that are clean and free from dirt, concrete, and other debris.
      a. Coat with form release agent if required, prior to use or reuse.

2.02 MANUFACTURED UNITS

A. Forms: Built-up plywood:
   1. Built-up plywood forms may be substituted for prefabricated forming system subject to following minimum requirements:
      a. Size and material:
         1) Use full size 4-foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
         2) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
      b. Wales: Minimum 2-inch by 4-inch lumber.
      c. Studding and wales: Contain no loose knots and be free of warps, cups, and bows.

B. Forms: Steel or steel framed:
   1. Steel forms:
      a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
      b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
   2. Steel framed plywood forms:
      a. Provide forms that are rigidly constructed and capable of being braced.
      b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

C. Form release agent.
   1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.

D. Form ties:
   1. General:
      a. Provide form ties for forming system selected that are manufactured by recognized manufacturer of concrete forming equipment.
      b. Do not use wire ties or wood spreaders of any form.
      c. Provide ties of type that accurately tie, lock, and spread forms.
      d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
      e. Do not allow holes in forms for ties to allow leakage during placement of concrete.
   2. Cone-snap ties:
      a. Cone-snap ties shall form a cone shaped depression in the concrete with minimum diameter of 1 inch at the surface of the concrete and minimum depth of 1-1/2 inches.
      b. Provide neoprene waterseal washer that is located near the center of the concrete.
   3. Taper ties:
      a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.

E. Incidentals:
   1. External angles:
      a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
      b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion, and construction joints.
   2. Keyways: Steel, plastic, or lumber treated with form release agent.

PART 3 EXECUTION

3.01 EXAMINATION

A. Site verification of conditions:
   1. Do not place concrete until forms have been checked for alignment, level, and strength, and mechanical and electrical inserts or other embedded items for correct location.

3.02 INSTALLATION

A. Forms: Built-up plywood:
   1. Studding:
      a. Spaced at 16 inches or 24 inches on center.

b. Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
c. Install studs perpendicular to grain of exterior plys of plywood sheets.

2. Wales: Form wales of double lumber material with minimum size as specified in this Section.
3. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.

B. Forms: Steel or steel framed:
1. Steel forms:
a. Adequately brace forms for minimum deflection of finish surface.
2. Steel framed plywood forms:
a. Rigidly construct and brace with joints fitting closely and smoothly.
b. Number of form reuses: Depends upon durability of surface coating or overlay used.
3. Built-up plywood forms: As specified in this Section may be used in conjunction with steel forms or steel framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.

C. Form bracing and alignment:
1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
2. Formwork:
a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
b. Make adequate provisions for uplift pressure, lateral pressure on forms, and deflection of forms.
3. When second lift is placed on hardened concrete: Take special precautions in form work at top of old lift and bottom of new lift to prevent:
a. Spreading and vertical or horizontal displacement of forms.
b. Grout "bleeding" on finish concrete surfaces.
4. Pipe stubs, anchor bolts, and other embedded items: Set in forms where required.
5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.

D. Forms: Incidentals:
1. Keyways: Construct as indicated on the Drawings.
2. Reentrant angles: May be left square.
3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.
4. Inserts:
a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.
5. Pipe and conduit penetrations:
a. Install pipe and conduit in structures as indicated on the Drawings, and seal with materials as specified in Section 07_92_00 - Joint Sealants.

E. Form release agent:
   1. Apply in accordance with manufacturer's instructions.

F. Form ties:
   1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally.

3.03 FORM REMOVAL

A. General:
   1. Keep forms in place, as specified in the following paragraphs, to provide curing and to protect concrete surfaces and edges from damage.
   1. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Form removal:
   1. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until the following conditions are satisfied:
      a. Concrete has sufficient strength to allow form removal without damage to surfaces.
      a. At least 48 hours have elapsed since the end of concrete placement.
      b. Provisions are in place to maintain moisture for curing concrete, and temperature at or above the required minimum curing temperature specified.
   2. Vertical forms:
      a. Retain in place for a minimum of 24 hours after concrete is placed.
      b. If concrete has sufficient strength and hardness to resist surface or other damage after 24 hours, forms may be removed.
   3. Other forms supporting concrete, and shoring: Retain in place as follows:
      a. Formed sides of footings: 24 hours minimum.
      c. Formed vertical sides of beams, girders, and similar members: 48 hours minimum.
      b. Forms below slabs, beams, and girders: Until concrete strength reaches specified strength f'c or until shoring is installed.
         1) Shoring for slabs, beams, and girders: Shore until concrete strength reaches minimum specified 28-day compressive strength.

3.04 SURFACE REPAIRS AND FINISHING

A. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03_30_00 - Cast-in-Place Concrete.

B. Form ties: Remove form ties from surfaces. Fill tie holes as follows:
   1. Remove form ties from surfaces.
   2. Roughen cone shaped tie holes by heavy sandblasting before repair.
   3. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03_60_00 - Grouting.

4. Taper ties:
    a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
        1) Heavy sandblast and then clean tie holes.
        2) After cleaning, drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.
        3) Locate steel rod in cylindrical recess and against middle of plug during driving.
            a) At no time are plugs to be driven on flat area outside cylindrical recess.
    b. Dry-pack of taper tie holes:
        1) After installing plugs in tie holes, coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03_60_00 - Grouting.
            a) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
            b) Dry-pack the outside of the hole no sooner than 7 days after the inside of the hole has been dry packed.
            c) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
                (1) Cover with minimum of 10 mils of epoxy gel.
                (2) Provide epoxy gel coating on wall surfaces that extend minimum of 2 inches past dry-pack mortar filled tie holes.
                (3) Provide finish surfaces that are free from sand streaks or other voids.

3.05 TOLERANCES:

A. Finished concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.

B. Construct work within the tolerances in accordance with ACI 117, except as modified in the following paragraphs or as indicated on the Drawings.
    1. General:
        a. At certain locations in the Work, tolerances required for equipment placement and operation may be more restrictive than the general tolerance requirements of this Section.
        b. Confirm equipment manufacturers' required tolerances for location and operation of equipment that will be installed, and construct concrete to satisfy those requirements.
    2. Slabs:
        a. Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
        b. Slabs indicated to be level: Have maximum vertical deviation of 1/8-inch in 10-foot horizontal length without any apparent changes in grade.
    3. Circular tank walls:
        a. The Contractor may deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2 feet.

4. Inserts and embedments:
    a. Set inserts and embedments to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
    b. Maximum tolerances: As follows:

Item	Tolerance
Sleeves and inserts	Plus 1/8 Minus 1/8 inches.
Anchor bolts:	
Projected ends	Plus 1/4 Minus 0.0 inches.
Axial alignment	Not more than 2 degrees off the axis indicated on the Drawings.
Setting location	Plus 1/16 Minus 1/16 inches.
All embedments	Minimum 1 inch clearance from reinforcing steel.

    c. Securing embedded items in formwork by wiring or welding to reinforcement is not permitted.

C. Remove and replace work that does not conform to required tolerances. Procedures and products employed in and resulting from such re-work shall be acceptable to the Engineer.

END OF SECTION

SECTION 03_15_14

HYDROPHILIC RUBBER WATERSTOP

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Hydrophilic rubber waterstop.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
   2. D570 - Standard Test Method for Water Absorption of Plastics.
   3. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   4. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.

1.03 SUBMITTALS

A. General:
   1. Submit the following items for each type, style, and size of hydrophilic waterstop to be installed.
   2. Product data:
      a. Manufacturer’s product data sheets.
         1) Include complete physical dimensions, expansion characteristics, and laboratory test reports indicating that average material properties conform to the requirements specified.
         2) Provide data sheets for all materials to be included in the waterstop system.
   3. Samples:
      a. Minimum 6-inch long samples of each type of waterstop to be used if requested by the Engineer.
   4. Manufacturer's installation instructions:
      a. Installation instructions and recommended installation details for the complete waterstop system, and for each component used in that system.

PART 2 PRODUCTS

2.01 HYDROPHILIC RUBBER WATERSTOP

A. General:
   1. System composed of flexible hydrophilic urethane polymer with preformed strips, adhesives, paste, fasteners, and other accessories required for a complete and watertight installation.
      a. To ensure compatibility of materials, a single manufacturer shall provide all products and accessories for the hydrophilic waterstop system.
      b. Products incorporating bentonite are not acceptable under this Section.
      c. Provide waterstop and accessories resistant to degradation under cyclic wetting and drying and to chemicals typically found in water treatment structures.

B. Hydrophilic strip waterstop:
   1. Pre-formed strips of flexible hydrophilic rubber designed to undergo controlled expansion when exposed to moisture:
      a. Strips manufactured to limit expansion in directions parallel to the plane of the joint, and to direct expansion against confining material perpendicular to that plane.
   2. Provide normal or low-expansion pressure as scheduled and as indicated on the Drawings.
   3. Manufacturers: One of the following or equal:
      a. Hydrophilic strip:
         1) Adeka Ultra Seal USA, MC-2010MN.
         2) Sika Corp., Hydrotite CJ1020-2K.
      b. Low expansion hydrophilic strip:
         1) Adeka Ultra Seal USA, KBA-1510FP.
         2) Sika Corp., Hydrotite CJ0725-3K.

C. Hydrophilic paste waterstop.
   1. Single-component gun grade paste of hydrophilic rubber designed to undergo controlled expansion when exposed to moisture after initial curing.
   2. Manufacturers: One of the following or equal:
      a. Adeka Ultra Seal USA: P-201.
      b. Sika Corp., Leakmaster LV-Z.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and recommended details.

B. Prepare concrete joint surfaces:
   1. Use wire brushing or scraping to expose an uncontaminated, solid surface.

2. Clean prepared surface with high-pressure air or water to remove residue and debris.
3. Confirm that prepared surfaces conform to manufacturer's recommendations for surface profile and moisture conditions before installing materials.

C. Provide manufacturer's recommended lap, splice, and corner details for hydrophilic waterstops.
1. Use hydrophilic paste at all corner joints and overlap splices of hydrophilic strips.

D. Hydrophilic strip waterstop:
1. Install primers and adhesives when recommended by the manufacturer before setting hydrophilic strips.
2. Keep hydrophilic strip taut during the fastening process.
3. Secure hydrophilic strip in place with concrete nails, screws, or adhesive.
4. Provide installation with no gap between the hydrophilic strip and the concrete to which it is attached. At rough or irregular surfaces, set hydrophilic strip waterstop strip in a bead of hydrophilic paste.
   a. Fill all voids and rough areas under the hydrophilic strip with hydrophilic paste.
   b. Allow hydrophilic paste to cure in accordance with manufacturer's recommendations before encapsulating paste in fresh concrete.

3.02 SCHEDULE

A. At the following joint locations/conditions, use the hydrophilic strip waterstop configuration noted unless otherwise indicated on the Drawings.

B. Concrete construction joints:
1. Under all of the following conditions, use hydrophilic strip waterstop set in a bed of hydrophilic paste waterstop, and screw strip waterstop to concrete surface:
   a. Slab or wall thickness is greater than 10 inches.
   b. Waterstop is placed between 2 rows of steel reinforcement.
   c. Concrete cover from waterstop to nearest concrete face is at least 4 inches.
2. Under any one of the following conditions, use low-expansion hydrophilic strip waterstop set in bed of hydrophilic paste waterstop and screw strip to concrete surface:
   a. Waterstop is placed on 1 side of a single row of steel reinforcement.
   b. Concrete cover from waterstop to nearest concrete face is less than 4 inches.

C. Pipe penetrations through concrete:
1. Pipe diameter less than 4 inches: Not allowed.
2. Pipe diameter of 4 to 24 inches: Continuous bead of hydrophilic paste waterstop, minimum 1/4-inch high by 1/2-inch wide, encircling pipe.
3. Pipe diameter greater than 24 inches: Continuous hydrophilic strip waterstop around perimeter of pipe, with hydrophilic paste seal at lapped ends of strip.

END OF SECTION

SECTION 03_20_00

CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Reinforcing bars:
      a. Carbon steel.
   2. Thread bars.
   3. Bar supports.
   4. Tie wires.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.
   2. SP-66 - ACI Detailing Manual.

B. American Iron and Steel Institute (AISI).

C. American Welding Society (AWS):
   1. D1.4 - Structural Welding Code - Reinforcing Steel.

D. ASTM International (ASTM):
   1. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
   2. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.

E. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice.

1.03 DEFINITIONS

A. Architectural Concrete: Concrete surfaces that will be exposed to view in the finished work.
   1. Additionally, for purposes of this Section,includes:
      a. Concrete surfaces that are designated to receive paints or coatings.
      b. Exposed concrete in open basins, channels, and similar liquid containing structures:Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.

B. Bars: Reinforcement or reinforcing bars as specified in this Section.

C. Evaluation Report: Report prepared by ICC-ES , or by other testing agency acceptable to the Elongineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01_41_00 - Regulatory Requirements.

D. Give Away Bars: Reinforcing bars that are not required by the Contract Documents, but are installed by the Contractor to provide support for the required reinforcing bars.

E. Wire Supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

1.04 SUBMITTALS

A. General:
   1. Submit in accordance with Section 01_33_00 - Submittal Procedures.
   2. Changes to reinforcement in Contract Documents:
      a. Indicate in a separate letter submitted with shop drawings any changes to reinforcement indicated on the Drawings or specified.
      b. Such changes will not be acceptable unless Engineer has accepted them in writing.

B. Product data:
   1. Bar supports:
      a. Wire bar supports:
         1) Schedule of support materials to be provided and locations of use.

C. Shop drawings:
   1. Reinforcement shop drawings:
      a. Submit drawings showing bending and placement of reinforcement required by the Contract Documents.
      b. Clearly indicate structures or portions of structures covered by each submittal.
      c. Shop drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and ACI SP-66.
      d. Use the same bar identification marks on bending detail drawings, placement drawings, and shipping tags.
      e. Submittals consisting solely of reinforcing bar schedules, without accompanying placement drawings, will not be accepted unless accepted under prior written agreement with Engineer.
   2. Reinforcement placement drawings:
      a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
      b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
      c. Show anchor bolt locations based on anchor bolt templates for approved equipment.
      d. Show splice locations.

3. Reinforcement fabrication drawings:
    a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.
    Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.

D. Samples (when requested by Engineer):
1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.

E. Test reports:
1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
    a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
    b. In such cases, submit certificates under the shop drawing submittal number with the letter "R" (for record date) appended to the end (e.g., of the reinforcement was submitted as 03_20_00-002-1, deliver the associated mill certificate as submittal 03_20_00-002-1R).

F. Manufacturer's instructions.

G. Special procedures:
1. Welding procedures conforming to AWS D1.4 for reinforcement to be field welded.
    a. Procedures qualification record.

H. Qualifications statements:
1. Welder qualifications.

I. Closeout documents:
1. Field quality control and inspection reports.
2. Field quality assurance special inspection and testing reports.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Deliver bars bundled and tagged with identifying tags.

B. Acceptance at site:
1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

1.06 SEQUENCING AND SCHEDULING

A. Bar supports:
   1. Do not place concrete until samples and product data for bar supports have been accepted by Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. The drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

2.02 MATERIALS

A. Reinforcing bars:
   1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
   2. Reinforcing bars:
      a. ASTM A615 Grade 60 deformed bars, including the following requirements:
         1) Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
         2) Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
   3. Reinforcing bars designated or required to be welded:
      a. Low-alloy, ASTM A706 Grade 60, deformed bars.

B. Bar supports:
   1. Wire supports:
      a. All stainless steel bar supports:
         1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire conforming to ASTM A493, AISI Type 316.
      b. Stainless steel protected bar supports:
         1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold--drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
         2) Stainless steel wire ends shall conform to ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
      c. Bright basic wire bar supports.
         1) Conforming to CRSI Manual if Standard Practice, Class 3.
   2. Plastic supports:
      a. Manufacturers: The following or equal:
         1) Aztec Concrete Accessories.

3. Deformed steel reinforcing bar supports:
    a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
4. Precast concrete bar supports ("dobies"):
    a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
    b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
    c. Block dimensions:
        1) Height to provide specified concrete cover.
        2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.

C. Tie wires:
1. General use: Black annealed steel wire, 16-gauge or heavier.

D. Welded wire fabric reinforcement:
1. Material:
    a. Carbon steel conforming to ASTM A1064.
2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
3. Fabric may be used in place of reinforcing bars if accepted by Engineer:
    a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.03 FABRICATION

A. Shop fabrication and assembly:
1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.
2. Bend bars cold. Use bending collars to develop the recommended bend radius.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
1. Reinforcing bars and welded wire reinforcement:
    a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.

2. Welded wire fabric:
    a. Verify that sheets are not curled or kinked before or after installation.

3.02 PREPARATION

A. Surface preparation:
    1. Reinforcing bars - uncoated:
        a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
        b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
        c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

3.03 INSTALLATION

A. Reinforcing bars: General:
    1. Field-cutting of reinforcing bars is not permitted.
    2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.

B. Placing reinforcing bars:
    1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
    2. Tolerances for placement and minimum concrete cover: As listed in Table 1.

Table 1 - Reinforcement Placing Tolerances

Member	Tolerance on Reinforcement Location (1)	Tolerance on Minimum Concrete Cover (1,2)
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	± 3/8 inch	- 3/8 inch
More than 10 inches thick	± 1/2 inch	- 1/2 inch
Formed soffits:	As noted above	- 1/4 inch
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below:	± 2 inches	- 1/2 inch
At discontinuous ends of brackets and corbels	± 1/2 inch	- 1/4 inch
At discontinuous ends of other members:	± 1 inch	- 1/2 inch

Notes:
(1) ± indicates "plus or minus;" - indicates "minus;" + indicates "plus."
(2) Tolerance on cover is limited as noted, but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.

3. Spacing between bars:
    a. Minimum clear spacing between bars in a layer:
        1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
    b. Minimum clear spacing between bars in 2 or more parallel layers:
        1) Place bars in upper layers directly above bars in lower layers.
        2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
    c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.
4. Lap splices for bars:
    a. Lap splice locations and lap splice lengths: as indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
    b. Unless otherwise specifically indicated on the Drawings (and noted as "non-contact lap splice"), install bars at lap splices in contact with each other and fasten together with tie wire.
    c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
    d. Stagger lap splices where indicated on the Drawings.
    e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.

C. Reinforcing supports:
1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
    a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use "give away bars" that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2 - Reinforcement Support Materials		
Case	**Location**	**Material**
a.	Concrete placed over earth and concrete seal slabs ("mud mats"):	Stainless steel wire supports on stainless steel plates.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings):	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	All stainless steel bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	All stainless steel bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

D. Tying of reinforcing:
   1. Fasten reinforcement securely in place with wire ties.
   2. Tie reinforcement at spacings sufficient to prevent shifting.
      a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
   3. Tie slab bars at every intersection around perimeter of slab.
   4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:

Table 3 - Maximum Spacing of Tie Wires for Reinforcement		
Bar Size	**Slab Bar Spacing (inches)**	**Wall Bar Spacing (inches)**
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

   5. After tying:
      a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
      b. Remove tie wire clippings from inside forms before placing concrete.

E. Welded wire fabric reinforcement:
   1. Install only where indicated on the Drawings or accepted in advance by Engineer.

2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
3. Straighten welded wire fabric to make sheets flat in the Work.
4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
    a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to Engineer.
5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
6. Lap splice welded wire fabric as indicated on the Drawings.
    a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.

F. Welding reinforcing bars:
1. Weld reinforcing bars only where indicated on the Drawings or where acceptance is received from Engineer prior to welding.
2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by Engineer.
    a. Conform to requirements for minimum preheat and interpass temperatures.
3. Submit:
    a. Welding procedures specification.
    b. Procedures qualification record.
    c. Welder qualification test record.
4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Provide quality control for the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Field inspections and testing:
1. Submit records of inspections and testing to Engineer in electronic format within 24 hours after completion.

3.05 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01_45_00 - Quality Control.

B. Special inspections and tests:
1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.
2. Frequency of inspections:
    a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01_41_00 - Regulatory Requirements.
3. Preparation:
    a. Review Drawings and Specification for the Work to be observed.
    b. Review approved submittal sand shop drawings.

4. Inspections: Special inspection shall include, but is not limited to, the following items.
    a. Reinforcement: General:
        1) Type (material) and location of reinforcement supports.
        2) Bar material/steel grade and bar size.
        3) Location, placement, and spacing of bars.
        4) Clear concrete cover over reinforcement.
        5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings).
        6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
        7) Reinforcement tired in position and tie wire legs turned inward toward the center of the concrete section.
    b. Reinforcement: Welding:
        1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
        2) Provide periodic inspection for:
            a) Weldability of reinforcement other than ASTM A706.
            b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
        3) Provide continuous inspection for:
            a) Other welds.
            b) Welds at mechanical reinforcing bar couplers and end anchors.
        4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
5. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspections.

3.06 NON-CONFORMING WORK

A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION

SECTION 03_21_17

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in concrete using adhesives.

1.02 REFERENCES

A. American Concrete Institute (ACI).
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

C. ASTM international (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI).

E. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

F. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 DEFINITIONS

A. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the Building Code specified in Section 01_41_00 - Regulatory Requirements.

1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer's printed installation instructions (MPII).
   2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.

3. Handling and storage instructions.

B. Quality control submittals:
   1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01_41_00 - Regulatory Requirements.
   2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
   3. Installer qualifications:
      a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
      b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
   1. Inspections: Field quality control: Reports of inspections and tests.
      a. Inspections: Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installation requirements:
      a. Have available at the site, and install anchors in accordance with, the adhesive manufacturer's printed installation instructions.
   2. Installer qualifications:
      a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
      b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Building Official.
         1) Organizations/certification programs deemed to be qualified are:
            a) ACI-CRSI Adhesive Anchor Installer Certification Program.
            b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the Building Official.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
   1. Store adhesives and adhesive components on pallets or shelving in a covered-storage area protected from weather.
   2. Control temperature to maintain storage within manufacturer's recommended temperature range.
      a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.
   3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

A. As specified in Section 01_81_50 - Design Criteria.

B. Seismic Design Category (SDC) for structures: As specified in Section 01_81_50 - Design Criteria.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements or ACI 355.4 and of ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

2.02 EPOXY ADHESIVE

A. Materials:
   1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle.
      a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-RE 500-V3.
   2. Simpson Strong-Tie Co., Inc., SET-3G.

2.03 ALL THREAD RODS

A. Materials: As specified in Section 05_12_00 - Structural Steel Framing for rods, nuts, and washers.

2.04 REINFORCING BARS

A. As specified in Section 03_20_00 - Concrete Reinforcing.

PART 3 EXECUTION

3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Building Official.
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings.
   1. If embedment depth is not indicated, contact Engineer for requirements.

3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
   2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "conditions of use" stipulated in the Evaluation Report before beginning work.
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions, and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a "condition of use" in the Evaluation Report.
      a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.

D. Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth.
      a. Obtain Engineer's acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
      b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
      c. Epoxy grout may be substituted for dry-pack mortar when accepted by Engineer.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
   3. When existing reinforcing steel is encountered during drilling and when specifically accepted by Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.

4. Bent bar reinforcing bars: Where edge distances are critical, and interference with existing reinforcing steel is likely, if acceptable to Engineer, drill hole at 10-degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F. Cleaning holes:
   1. Insert air nozzle to bottom of hole and blow out loose dust.
      a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
      b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
   2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust.
      a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
      b. Repeat at least 4 times.
   3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
   4. Leave prepared holes clean and dry.
   5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
   6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
   1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
   2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
   1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
   2. Fill hole as nozzle is withdrawn without creating air voids.
   3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
   4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods.
   1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
   2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.

3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading.
1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all-thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.

3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
a. Provide notice of scheduled training to Engineer and to Special Inspector(s) not less than 10 working days before training occurs. Engineer and Special Inspector may attend training sessions.
2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
1. Hole drilling and preparation.
2. Results: Submit records of inspections and testing to Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
      b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
   3. Preparation:
      a. Review Drawings and Specifications for the Work to be observed.
      b. Review adhesive manufacturer's MPII and recommended installation procedures.
      c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
   4. Inspection: Periodic:
      a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
         1) Concrete: Class (minimum specified compressive strength) and thickness.
         2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
         3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "conditions of use" listed in the Evaluation Report.
         4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
         5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
      b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
         1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
         2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.

5. Inspection: Continuous.
    a. Make observations as described under "Inspection - Periodic, Initial Inspection" during all drilling, cleaning, and bonding activities for all bars and rods installed.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03_30_00

CAST-IN-PLACE-CONCRETE

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in-place concrete.

B. The requirements of this Section will require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. CODE-350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   3. PRC-212.3 - Report on Chemical Admixtures for Concrete.
   4. PRC-302.1 - Guide to Concrete Floor and Slab Construction.
   5. PRC-305 - Guide to Hot Weather Concreting.
   6. PRC-306 - Guide to Cold Weather Concreting.

B. ASTM International (ASTM):
   1. C29 - Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   8. C94 - Standard Specification for Ready-Mixed Concrete.
   9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
   10. C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
   11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
   12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29. C595 - Standard Specification for Blended Hydraulic Cements.
30. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
31. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
32. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
33. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
34. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
35. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
36. C1240 - Standard Specification for Silica Fume Used in Cementitious Mixtures.
37. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
38. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
39. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
40. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
41. D29 - Standard Practice for Determining Volatile and Nonvolatile Content of Cellulosics, Emulsions, Resin Solutions, Shellac, and Varnishes.
42. D75 - Standard Practice for Sampling Aggregates.
43. D2103 - Standard Specification for Polyethylene Film and Sheeting.

44. D3665 - Standard Practice for Random Sampling of Construction Materials.
45. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Alkali: The sum of sodium oxide and potassium oxide calculated as sodium oxide.
   2. Alkali Load: Amount of alkalies contributed by the Portland cement in a concrete mixture, expressed in pounds per cubic yard (lb/yd^3) and calculated by multiplying the Portland cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement, or the Portland cement portion of a blended cement, divided by 100.
   3. Architectural Concrete: Concrete surfaces that will be exposed to view in the finished work.
      a. For purposes of this Section, includes only those surfaces that receive paint or coatings.
      b. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03_35_29 - Tool Concrete Finishing.
      c. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view of located above the grade line as defined in Section 03_35_29 - Tool Concrete Finishing.
   4. Average Daily Temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.
   5. Cementitious Materials: Portland cement or blended cement and supplementary cementitious materials.
   6. Class of Concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
      a. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
      b. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.
   7. Cold Weather: Includes one or more of the following conditions:
      a. Current air temperature is 45 degrees Fahrenheit and falling.
      b. Air temperature during the first 24 hours after placement is expected to fall into the range of 45 degrees Fahrenheit to 40 degrees Fahrenheit.

c. A period when, for more than 3 consecutive days, the following conditions exist:
    1) The average daily air temperature drops below 40 degrees Fahrenheit.
    2) The air temperature is not greater than 50 degrees Fahrenheit for more than one-half of any consecutive 24-hour period.

8. Cold Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during cold weather.
9. Green Concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.
10. Hairline Crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).
11. Hot Weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and in this Section, Attachment A - Menzel Formula and Nomograph.
12. Hot Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.
13. Paste Content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.
14. Supplemental Cementitious Material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 DELEGATED DESIGN

A. Provide Delegated Design for the following Work, based on the requirements of this Section.
    1. Concrete mix designs.

1.05 SUBMITTALS

A. General:
    1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
    2. A maximum of 2 mix designs will be reviewed by the Engineer for each class of concrete required.
        a. Review of additional mix designs shall be at the expense of the Contractor.

B. Product data:
    1. Submit data completely describing products and demonstrating compliance with the requirements of this Section.
    2. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.

3. Admixtures:
    a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
    b. If air entraining admixture requires test method other than ASTM C173 to accurately determine air content, make special note of requirements in Submittal.
4. Curing compound: Submit complete data on proposed compound.

C. Design data:
1. Concrete mix designs:
    a. Submit full details, including mix design calculations and plots, for concrete mixes proposed for use for each class of concrete.
    b. Include mix design calculations of proportions by both weight and volume.
    c. Determine and include the alkali load of the proposed mix.
    d. Include information on correction of batching for varying moisture contents of fine aggregate.
    e. Submit source quality test records with mix design Submittal.
    f. Provide calculations demonstrating that the mixes proposed provide the required average compression strength of concrete (f'cr) based on source quality test records.
    g. For each Class A mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
    h. For each Class A mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

D. Concrete mixes - Trial batches:
1. Drying shrinkage test results.
    a. Submit results of testing.
2. Compression strength test results.
    a. Submit results of testing. Provide data for each cylinder tested.
    b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
    c. Submit test specimens from compression strength tests for trial batches.
        1) Using indelible marker, clearly label each cylinder with concrete class, trail batch number, and specimen number.
3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

E. Test reports:
1. Dated not more than 24 months prior to the date of Submittal.
2. Aggregate:
    a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
    b. Sieve analyses:
        1) During construction, submit sieve analyses of coarse, fine, and combined aggregates used any time there is a change in supplier, or a significant change in the character and/or grading of materials, and when requested by the Engineer.

c. Aggregates - coarse:
    1) Physical properties:
        a) Sieve analysis.
        b) Percentage of particles having flat and/or elongated characteristics.
        c) Abrasion loss.
        d) Soundness.
    2) Deleterious substances:
        a) Clay lumps and friable particles content.
        b) Materials finer than 200 sieve (percentage).
        c) Shale and chert content.
        d) Coal and lignite content.
    3) Alkali reactivity.
    4) Deleterious substances:
        a) Clay lumps and friable particles content.
        b) Chert and shale content.
        c) Coal and lignite content.
        d) Materials finer than No. 200 sieve.
    5) Alkali reactivity.
d. Aggregates - Fine:
    1) Physical properties:
        a) Sieve analysis and fineness modulus.
        b) Soundness.
    2) Deleterious substances:
        a) Clay lumps and friable particles (percentage).
        b) Materials finer than No. 200 sieve (percentage).
        c) Coal and lignite (percentage).
        d) Shale and chert.
        e) Organic impurities (“Color” as determined by ASTM C40).
    3) Alkali reactivity.
e. Aggregates - Combined:
    1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, Number 4, Number 8, Number 16, Number 30, Number 100, Number 200.
    2) Bulk density in accordance with ASTM C29.
    3) Void content in accordance with ASTM C29.
    4) Submit at:
        a) Initial mixture design Submittal.
        b) Intervals of not more than 4 weeks.
        c) Any time there is a change in character or grading of constituent materials.
        d) When requested by the Engineer.

3. Cement:
    a. Mill tests, including alkali content measured as equivalent alkalies, for each shipment of cement included in the Work.
        1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.

4. Supplemental cementitious material:
    a. Fly ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
        1) Include supplier's report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na_2Oe).
    b. Slag cement: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C989 and this Section.
    c. Silica fume: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C1240 and this Section.

F. Certificates:
    1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.

G. Source quality control Submittals:
    1. Truck batch tickets for each load of concrete delivered to the site, whether accepted or rejected.
    2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
        a. Names and qualifications of key quality control personnel:
            1) Quality control manager.
            2) Testing and inspection personnel.
        b. Names and qualifications of testing laboratories:
            1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
        c. Example forms for: Inspection reports, certificates of compliance, and test results.
        d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
            1) Daily testing of aggregate gradation.
            2) Monthly testing of cement quality.
            3) Monthly testing of fly ash quality.
        e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying Contractor and Engineer of non-conformances.
        f. Procedures for verifying that:
            1) Materials are properly stored during concrete batching operations.
            2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
            3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
            4) Delivery trucks have a valid NRMCA certification card.
        g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
            1) Cement and supplementary materials are from sources designated in the approved Submittals.

2) Concrete as-batched complies with the constituent weights designated in the approved Submittals.
3) Corrections for aggregate moisture are being correctly applied.
4) Any mix water withheld from the batch.

h. Procedures for visually inspecting concrete during discharge.

H. Field quality control Submittals:
1. Contractor's notifications of readiness for concrete placement.
2. Contractor's reports of field quality control testing.
a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.
b. Testing results for slump, temperature, unit weight, and air entrainment.
c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.
d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added on site as “Max add water.” Record on the batch ticket the volume of water actually added at site.
e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.

I. Special procedure Submittals:
1. Sequence of concrete placing:
a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
2. Cold weather concreting plan.
3. Hot weather concreting plan.
4. Repair of defective concrete: Submit mix design for repair materials to be used.

1.06 QUALITY ASSURANCE

A. Pre-installation meetings:
1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
a. Provide additional meetings if necessary, to discuss specific concrete Submittals, mixes, or placing and curing conditions.
b. Notify Engineer of location and time of each conference.
2. Required attendees:
a. Contractor including Contractor's superintendent and key personnel.
b. Concrete supplier.
c. Technical representative(s) of supplier(s) of concrete admixtures.
d. Subcontractor(s) providing pumping, placing, finishing, and curing.
e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
f. Sampling and testing personnel.
g. Engineer.
h. On-site inspectors representing Engineer.
i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.

3. Agenda:
    a. Review of requirements of Drawings and Specifications.
    b. Project and product safety requirements.
    c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
    d. Contractor's schedule for cast-in-place concrete work.
    e. Mix designs, mix tests, and Submittals.
    f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the site.
    g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
    h. Slump and limits on placing time or conditions to maintain placeability.
        1) Field adjustment of slump and air content.
    i. Procedures for finishing, curing, and retention of moisture during these operations.
    j. Procedures and protection for hot and cold weather conditions.
    k. Requirements and coordination for inspections.
        1) Responsibility for test specimen curing and storage.
        2) Distribution of test reports.
    l. Other Specification requirements requiring coordination between parties to the work.
4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01_31_19 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
    1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
    2. Deliver and store packaged materials in original containers until ready for use.
    3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.

B. Acceptance at site:
    1. Reject material containers or materials showing evidence of water or other damage.
    2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

1.08 PROJECT CONDITIONS

A. Cold weather concreting: During periods of cold weather as defined in this Section, implement cold weather concreting procedures in this Section.

B. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

1.09 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.

B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. It is the intent of this Section to secure, for every part of the Work, concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.

B. It is the intent of this Section to procure a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.

C. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of Portland cement or blended cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
      b. Proportion aggregates to produce a gradation of aggregate that combines fine coarse aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. The gradation should maximize long-term durability and strength of the concrete mixture.
      c. Durability requirements will be deemed to be satisfied when:
         1) The mixture is proportioned with a well-graded combined aggregate.
         2) The specified water-cement ratio is satisfied.
         3) The concrete contains the specified range of air content.
         4) The maximum specified paste content is satisfied.
      d. Proportion materials in a manner that will secure the lowest cement content, water-cementious materials ratio, and paste volume that is consistent with good workability that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.
      e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of to reduce the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
      f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.
   2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices, and as set forth in ACI CODE-318, and ACI CODE-350.

2.02 MATERIALS - GENERAL

A. Water and ice:
   1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
   2. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.

2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

A. Water and ice:
   1. As specified in the preceding paragraphs.

B. Cementitious materials:
   1. Portland cement:
      a. In accordance with ASTM C150.
         1) Type II, or Type II(MH) as scheduled for each mix.
      b. Single source: To provide uniformity of appearance, for each structure use only one source, type, and brand of Portland cement for walls and slabs that will be exposed in the finished work.
         1) Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
      c. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.
   2. Blended hydraulic cement:
      a. In accordance with ASTM C595:
         1) Type IP (MS).
         2) Type IL (MS).
         3) Type IS (<70)(MS).
      b. Single source: To provide uniformity of appearance and quality, for each structure use only 1 source, type, and brand of cement.
      c. Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
      d. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.

C. Supplementary cementitious materials:
   1. Fly ash:
      a. Class C or Class F fly ash in accordance with the requirements of ASTM C618, except as modified in this Section.
         1) Class C may be used in concrete made with Type II Portland cement.
         2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
            a) CaO content: Less than 18 percent.
      b. Loss on ignition: Not exceeding 3 percent.
      c. Replace Portland cement at ratio of 1.0 pound fly ash for each pound of cement, up to minimum and maximum replacement as specified in “Requirements for Mix Proportioning.”

2. Slag cement:
    a. Grade 80, 100, or 120 in accordance with ASTM C989, except as modified below:
        1) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
        2) Total alkalies Na2O + 0.658 K2O:
            a) Minimum: 0.60 percent.
            b) Maximum: 0.90 percent.
3. Silica fume:
    a. Provide silica fume in accordance with ASTM C1240, except as modified below:
        1) Moisture content: 3 percent maximum.
        2) Loss on ignition: 6 percent maximum.
        3) Reactivity with cement alkalies: 80 percent minimum.
        4) Sulfate resistance: Maximum 0.05 percent expansion at 6 months 0.05 percent expansion at 1 year.

D. Admixtures:
1. General:
    a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
    b. Admixtures shall be compatible with concrete constituents and with other admixtures.
        1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.
        2) Admixture manufacturers: One of the following, or equal.
            a) Master Builders Solutions.
            b) Euclid Chemical.
            c) GCP Applied Technologies (formerly W.R. Grace).
            d) Sika Corp.
    c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
    d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
    e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.
2. Air entraining admixture (AEA):
    a. In accordance with ASTM C260 and dosed to provide entrained air percentages specified in this Section.
    b. Provides entrained air as bubbles, evenly dispersed at the time of placement and during curing.
3. Water reducing admixture(WRA):
    a. May be used at the Contractor's option.
    b. Conforming to ASTM C494, Type A (water-reducing).
        1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
    c. Not containing air-entraining agents.
    d. Liquid form before adding to the concrete mix.

4. Shrinkage reducing admixture (SRA):
    a. May be used at Contractor's option.
        1) Provide shrinkage reducing admixture in sufficient dosage so as to produce shrinkage within the limits specified.
    b. Not containing expansive agents.
    c. In accordance with ASTM C494, Type S (specific performance).
    d. One of the following, or equal:
        1) Master Builders Solutions: SRA Series.
        2) Euclid Chemical: Eucon SRA Series.
        3) GCP Applied Technologies: Eclipse Series.
5. Set-controlling admixtures:
    a. Shall not be used without prior acceptance from Engineer.

E. NOT USED

F. Aggregate:
1. General:
    a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
    b. Provide aggregates to produce in place concrete with unit weight as follows:
        1) Normal weight concrete: Not less than 140 pounds per cubic foot.
    c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
    d. Do not use aggregate recycled from fresh concrete returned to the batching facility.
2. Alkali-silica reactivity:
    a. Provide aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, and not greater than 0.04 percent at 1 year when tested in accordance with ASTM C1293.
3. Fine aggregate:
    a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
    b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
    c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs:
        1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.

2) Deleterious substances: Not in excess of the percentages by weight specified in Table 1 of this Section.

Table 1: Fine Aggregate, Limits on Deleterious Substances		
Item	**Test Method**	**Percent (maximum)**
Materials finer than No. 200 sieve(2)	ASTM C117	3.00(2)
Clay lumps and friable particles	ASTM C142	1.00
Lightweight particles (SG < 2.40)	ASTM C123	1.00
• Chert or shale(1)	ASTM C295	1.00(1)
Coal and lignite	ASTM C123	0.50

Notes:

(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required.

(2) For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.

3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than “standard color” when tested in accordance with ASTM C40.

4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.

4. Coarse aggregate:
   a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
   b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.
   c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs:
      1) Grading:
         a) Size number as specified in ASTM C33, and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
         b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.

2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

Table 2: Coarse Aggregate, Limits on Impurities		
Item	**Test Method**	**Percent (maximum)**
Clay lumps and friable particles	ASTM C142	0.50
Lightweight particles (SG < 2.40)	ASTM C123	1.25
• Chert or shale(1)	ASTM C295	1.00(1)
Materials finer than No. 200 sieve	ASTM C117	0.50(2)
Coal and lignite	ASTM C123	0.25

Notes:

(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required.

(2) When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.

3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.
4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

2.04 MATERIALS FOR PLACING, CURING AND FINISHING

A. General:
   1. Materials shall be compatible with concrete and with other materials.

B. Cement grout:
   1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
   2. As specified in Section 03_60_00 - Grouting.

C. Concrete sealer:
   1. As specified in Section 03_35_29 - Tooled Concrete Finishing.
   2. Not for use in water-containment structures.

D. Evaporation retardant:
   1. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
   2. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
   3. Manufacturers: One of the following or equal:
      a. Master Builders Solutions, MasterKure ER 50.
      b. Euclid Chemical Co., Eucobar.

E. Nonslip abrasive:
   1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
   2. Manufacturers: One of the following or equal:
      a. Exolon Co.
      b. Abrasive Materials, Inc.
      c. “Non-Slip Aggregate”, Euclid Chemical Co.

F. Plastic membrane for curing:
   1. Polyethylene film: In accordance with ASTM C171.
   2. Properties:
      a. Color: White.
      b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
      c. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

G. Sprayed membrane curing compound:
   1. Combination curing and sealing products (“cure and seal”) will not be permitted.
   2. Properties:
      a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.
      b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
         1) It shall include a white, reflective fugitive dye.
         2) Moisture loss during a 72-hour period shall not exceed 9 pounds per cubic yard when tested in accordance with ASTM C156.

H. Surface-applied sealing system:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Vandex Super.
      b. Kryton International, Inc., Krystol T1.
      c. Xypex Chemical Corp., Xypex Concentrate.
   2. Where surface-applied sealing system is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

2.05 EQUIPMENT

A. General:
   1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.

B. Batching equipment, or batch plant.
   1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.

C. Mixing equipment:
   1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
   2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
      a. Maintain concrete mixing equipment in good working order, and operate at loads, speeds, and timing recommended by manufacturer or as specified.
      b. Proportion cementitious materials and aggregate by weight.
   3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
   6. Retempering of concrete will not be permitted.
   7. Discharge entire batch before recharging.
   8. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
   9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
   10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
   11. Transit-mixed concrete:
      a. Mix and deliver in accordance with ASTM C94.
      b. Total elapsed time between addition of water at batch plant and discharging completed mix.
      c. Not to exceed 90 minutes.
      d. Elapsed time at project site shall not exceed 30 minutes.
      e. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
      f. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
   12. Continuously revolve drum after it is once started until it has completely discharged its batch:
      a. Do not add water until drum has started revolving.
      b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: For other types of mixers, mixing shall be as follows:
   1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.

2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.06 CONCRETE MIXES

A. General:
   1. Develop and provide mix design for each Concrete Class listed in Table 3 of this Section.
   2. Select and proportion mixes and document properties using 1 of the 2 methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
      a. Field experience method.
      b. Trial batch method.
   3. Organize and submit mix designs with data on all constituent materials and products for that mix for Engineer's review.
   4. Do not place concrete until the mix design for that Concrete Class has been accepted by Engineer.
   5. After acceptance, do not modify accepted mixes or provide new mixes without Engineer's prior review and acceptance of the proposed alternative.
      a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.
      b. For any change to approved mixes, Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
      c. For any change to approved mixes, make modifications within limits set forth in this Section.
      d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete and shall require full re-submittal of all data describing mix constituents, design, and testing.
   6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
   2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
   4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
   5. Weighing cementitious materials:
      a. Weigh cementitious materials separately.

b. Cement in unbroken standard packages (sacks): Need not be weighed.
c. Weigh bulk cementitious materials and fractional packages.

6. Measure mixing water by volume or by weight.

C. Requirements for mix proportioning:
1. Develop and provide mixes that:
a. Can be readily worked into corners and angles of forms and around reinforcement, without excessive vibration, and without permitting materials to segregate or free water to collect on surface.
b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
2. Constituent materials:
a. Provide concrete mixes composed of Portland cement or blended cement, blended aggregates, admixtures and water.
1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific Concrete Class are optional and may be included at the discretion of the Contractor based on Contractor's planned means and methods of construction.
b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
3. Minimum specified compressive strength:
a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.
b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days. If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.
4. Proportions and consistency:
a. Ratio of water to cementitious materials, and cementitious materials content:
1) Conform to maximum and minimum cementitious material content requirements specified in Table 3 of this Section.
2) Cementitious materials content: Consisting of Portland cement or blended cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
a) Fly ash content:
(1) Minimum: 15 percent of the total weight of cementitious materials.
(2) Maximum: 25 percent of the total weight of cementitious materials.
b) Slag cement content:
(1) Minimum: 20 percent of the total weight of cementitious materials.
(2) Maximum: 50 of the total weight of cementitious materials.

c) Silica fume content:
(1) Minimum: 4 percent of the total weight of cementitious materials.
(2) Maximum: 12 of the total weight of cementitious materials.

b. Aggregate size and content:
1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.
a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart ("Tarantula Curve").
b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.
c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.

c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.
1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.
2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.
3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.
4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.

d. Paste content: Limited to the following:
1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.
2) Class A mixes with air entrainment: Maximum 28 percent measured by volume plus the target air content.
3) Paste content shall be limited to 200 percent of the void content of the combined aggregate gradation determined by ASTM C29.

e. Total water content:
1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.

f. Coarseness/workability (Shilstone Method):
1) Proportion mixes to fall into the "Optimal" zone (Zone II) when plotted on the Coarseness Factor Chart ("Coarseness Factor" versus "Workability Factor") included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.

2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8 inch sieve, divided by the percent of the combined aggregate gradation retained on the Number 8 sieve, multiplied by 100, or:

$$CF = \frac{(\%\text{ retained on 3/8 in sieve})}{(\%\text{ retained on No. 8 sieve})} \times 100$$

3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the Number 8 sieve, adjusted for cement content in the mix.
   a) Determine volume of total cementitious material in the mix.
   b) For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
   c) For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
   d) Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564 pound basis.
   e) Example:
   650 pounds per cubic yard = 564 pounds + 86 pounds.
   Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete Classes for use in the Work:
   1. Provide concrete classes listed in Table 3 of this Section.
   2. Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
   3. Pumped concrete:
      a. Provide pumped concrete that complies with all requirements of this Section.
      b. Mixes placed by pumping shall be considered a sub-class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.
   4. Class PM concrete: In addition to the requirements of Table 3 of this Section, conform to the following:
      a. Minimum 28 day flexural strength: 650 psi when tested in accordance with ASTM C293.
      b. Cementitious materials content: 75 percent Portland cement plus 25 percent Class F fly ash (by weight), blended cement conforming to Type IP(25), or 75 percent Type IL blended cement plus 25 percent Class F fly ash (by weight).
      c. Aggregate:
         1) Minimum 55 percent coarse aggregate conforming to ASTM C33 size number 357 or size number 467.
         2) Substitute ASTM C33 size number 57 or size number 67 if mechanical paving equipment is not used.

Table 3: Concrete Classes									
Concrete Class[1]	**Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch)**	**Ratio of water to cementitious materials[3] (minimum - maximum).**	**Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4]**	**Cement Type**	**Maximum Chloride Content (percent by weight of cement)**	**Maximum Size of Coarse Aggregate (ASTM C33)**	**Air Entrainment (percent), (n/a: not applicable)**	**Admixtures required[4,5,6]**	**Slump Range (inches)**
A	4,500	0.40 to 0.42	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.15	#57	6±1.5	AEA WRA	2 to 4

Notes:

(1) Sub classes within major concrete classes are designated as follows:
NA: Without air entrainment.

(2) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.

(3) W/C Ratio = Ratio of water to cementitious materials by weight. Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.

(4) Cementitious material includes Portland cement plus supplemental cementitious materials. If trial batch testing demonstrates that the required strength cannot be met at 28 or 56 days with the specified combined aggregate gradation and the paste content limits, cementitious material content may be increased with Engineer's approval.

(5) Admixtures are designated as follows:
AEA: Air entraining admixture.
HRWR: High-range water-reducing admixture.
PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions.
SFR: Synthetic fiber reinforcement.
SRA: Shrinkage-reducing admixture.
WRA: Water-reducing admixture.

E. Install Concrete Classes in accordance with the following requirements unless otherwise indicated on the Drawings.
   1. Class A concrete: Structural concrete.
      a. Use Class A concrete at all locations unless other Classes are specified or indicated on the Drawings.

F. Concrete mix design documented by field experience:
    1. Mix design:
        a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for materials to be used in the mix for Engineer's review.
    2. Historical records for similar mix.
        a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
        b. Historical record - Materials:
            1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
            2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
                a) Documentation that the same concrete supplier will provide both mixes.
                b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
                c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
                d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
                e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.
        c. Historical record - Testing:
            1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
            2) Only records satisfying the following requirements will be accepted.
                a) All tests were conducted within a period of 1 year preceding the date of the Submittal.
                b) All tests were conducted over a period including not less than 45 days.
                c) The record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
                d) The record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
                e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
                f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".
                g) Provide supplementary testing if requested by Engineer.

d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
    1) Acceptance criteria:
        a) Slump: All tests within limits specified for record mix.
        b) Compressive strength: Average compression strength for tests, as determined by ACI CODE-350 not less than minimum required average strength.
        c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for “concrete mix design documented by trial batch preparation and testing”.

G. Concrete mix design documented by trial batch preparation and testing:
1. Mix design and trial batches:
    a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for each combination of materials and proportions to be used for Engineer’s review.
        1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7- and 28-day compressive strength of the concrete.
        2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
    b. After materials and proposed mix designs have been accepted by Engineer, have trial batches for each concrete mix design prepared by Contractor's testing laboratory.
        1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
        2) Provide batches of sufficient quantity to determine slump, workability, consistency, setting time, and finishing characteristics, and to provide sufficient specimens for testing.
    c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
        1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
        2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.
2. Testing - Slump:
    a. Determine slump in accordance with ASTM C143.
    b. Acceptance criterion: Slump within range specified.
3. Testing - Compressive strength:
    a. Prepare 4 inch diameter by 8 inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
    b. Determine average compressive strength:
        1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
        2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 3 at 56 days.

3) Calculate average compression strength for 7 day tests, for 28 day tests, and for 56 day tests.
4) Calculate ratios for:
a) Average 7 day strength to average 28 day strength.
b) Average 28 day strength to average 56 day strength.

c. Determine the required average compressive strength for each mix, f'cr, as described in the following paragraphs:
1) Calculate required average compressive strength (f'cr) based on the minimum specified 28-day compressive strength, f'c, plus a standard deviation determined from the test history available for that mix.
2) Determine f'cr as specified in ACI CODE-350, except as modified in the following paragraphs:
a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for "concrete mix design documented by field experience". Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f'cr) for the mix.
b) Where fewer than 15 compressive strength tests at 28 days are available, determine minimum required compressive strength, (f'cr) from Table 4 of this Section.

Table 4: Required Average Compressive Strength, Fewer than 15 Tests Available

Minimum Specified Compressive Strength, f'c (pounds per square inch)	Required Average Compressive Strength, f'cr (pounds per square inch)
Less than 3,000	f'c + 1,000
3,000 to 5,000	f'c + 1,200
Over 5,000	f'c + 1,400

d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f'cr for that concrete mix design.

4. Testing - Chloride content:
a. Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.

5. Testing - Drying shrinkage - Prism specimens:
a. Class A (including A, A-NA, A-SP, and A-NA-SP) and Class PM: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157 Divide specimens into 2 groups of 5 specimens each: 1 group including shrinkage-reducing admixture, and 1 group without shrinkage-reducing admixture.

b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
    1) Remove drying shrinkage specimens from molds at age of 23 hours, plus or minus 1 hour, after trial batching.
        a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, for at least 30 minutes.
        b) Remove specimens from the water and wipe with a damp cloth.
        c) Measure to nearest 0.0001 inch to determine original length.
        d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit, plus or minus 3 degrees, for moist curing.
    2) Maintain submerged curing conditions at 73 degrees Fahrenheit, plus or minus 3 degrees, for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.
    3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.
    4) At periods of 14, 21, 28, and 56 days after batching, remove specimens from curing room and repeat measurements.
c. Drying shrinkage test report:
    1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.
    2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:
        a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.
        b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.
        c) Percentage of drying shrinkage from batching to date of measurement.
d. Drying shrinkage acceptance criteria:
    1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.
e. Mixes accepted by Engineer:
    1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to Engineer.
    2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.

2.07 SOURCE QUALITY CONTROL

A. Sample and test materials in accordance with the following requirements:
    1. Sampling, testing, and reporting frequency:
        a. In preparation for mix design submittals and trial batch tests.

b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
c. For each 10,000 cubic yards of concrete mix produced.
d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.

2. Supplemental cementitious materials.
   a. Sample and test fly ash in accordance with ASTM C311.
   b. Sample and test slag cement in accordance with ASTM C989.
   c. Sample and test silica fume in accordance with ASTM C1240.
3. Aggregate:
   a. Sample combined aggregate in accordance with ASTM D75 and D3665, and test for gradation in accordance with ASTM C136.
   b. At least once every 30 days, and when requested by the Engineer.
   c. Submit test results.
4. Cementitious materials:
   a. Sample and test cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 or ASTM C595, and additional requirements of this Section.
      1) Determine alkali content by method set forth in ASTM C114.
   b. At least once every 90 days, and when requested by the Engineer.
   c. Submit test results.

B. Batch materials in accordance with the following requirements:
1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.
2. Aggregates:
   a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.
   b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.
3. Admixtures:
   a. Batch solutions using mechanical batcher capable of accurate measurement.
   b. Air entraining admixture: Add to batch in portion of the mixing water, unless otherwise recommended by the admixture manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare and submit mix designs for each Concrete Class indicated in Table 3 of this Section.

B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.

C. Make provisions for monitoring weather conditions:
    1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
    2. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for cold weather concreting or hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
        a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.

D. Place no concrete without Engineer’s prior acceptance of conditions.

E. Notify the Engineer in writing that preparations are complete and ready for placement of concrete. Such notification shall indicate readiness - not just intention - to place concrete for the designated portion of the Work.
    1. Submit notification to Engineer on forms provided by or acceptable to the Engineer and bearing the signature of Contractor’s superintendent.
        a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.
    2. Submittal of notification will be Contractor’s certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
    3. Provide notification for Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

3.02 CONCRETE JOINTS

A. Locations of joints are indicated on the Drawings.
    1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
    2. Construct joints where indicated, and as indicated on the Drawings.
    3. Where joint locations are not indicated on the Drawings, submit Contractor's proposed locations for Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.

B. Time between placements of adjacent concrete separated by joints.
    1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
        a. Slabs.
        b. Walls.
    2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
        a. Walls over slabs.
        b. Slabs over walls.
        c. Slabs keyed into the sides of walls.

C. Edges of joints:
   1. Provide joints have edges detailed as indicated on the Drawings.
   2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.

D. Joint construction:
   1. Preparation of forms:
      a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
      b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
      c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal, and then flush cleaned surfaces with water.
   2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.
   3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
      a. Take special care to ensure that waterstops are secured in proper position.
      b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.
   4. Horizontal joints:
      a. As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03_60_00 - Grouting.
         1) Thickness: Not less than 1/2 inch or more than 1 inch.
      b. For wall placements above planned cold joints, placement of cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (“superplasticizers”), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

3.03 MEASURING AND BATCHING MATERIALS

A. Measurements of materials:
   1. Proportion and measure cementitious materials and aggregates by weight.
      a. Weigh cementitious materials separately.
      b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
      c. Cement in unbroken standard packages (sacks) need not be weighed.
   2. Mixing water: Measure by volume or by weight.
   3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
   4. Weighing and measuring devices:
      a. Use equipment designed and constructed specifically for that purpose.
      b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
      c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.

5. Measurements and measuring devices:
    a. Subject to review by the Engineer.

B. Batching:
1. Admixtures shall be added at the concrete batch plant.
2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
    a. The dosage and mixing is personally overseen by concrete supplier's trained technologist.
    b. Adequate mixing is provided after addition.
    c. The maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
    d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

3.04 MIXING AND TRANSPORTING

A. Machine mixing:
1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.
2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to project site for final mixing and addition of mixing water is not permitted.
3. Remixing of concrete that has started to take its initial set (“retempering”) is not permitted.
4. Discharge entire batch before recharging.
5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.

B. Transit-mixed concrete:
1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
2. Total elapsed time between addition of water at batch plant and discharging completed mix:
    a. Not to exceed 90 minutes or 300 revolutions of the mixing drum.
    b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
3. Temperature - minimum and maximum allowable during mixing and transporting:
    a. Minimum: 50 degrees Fahrenheit.
    b. Maximum: 90 degrees Fahrenheit.
4. Continuously revolve drum after it is started until it has completely discharged its batch.
    a. Do not add water until drum has started revolving.
    b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

C. Concrete delivery:
   1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
      a. Time of day concrete was batched, and time of day that discharge from the truck is complete.
      b. Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, pozzolan, and water.
      c. Concrete Class as defined in Table 3 of this Section.
      d. Type, brand, and quantity of each admixture in the batch.
      e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
         1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.
      f. Number of revolutions of transit truck at arrival on site, and total number of revolutions when discharge is complete.
      g. Volume of concrete delivered in the batch.
      h. Numerical sequence of the batch delivered for that placement.
   2. Additional water may only be added to the mix when the following conditions are fully satisfied:
      a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for Engineer’s observation before any additional water is added.
      b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
      c. The full concrete load is still within the truck's mixing drum, and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
      d. Volume of water added, and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.
   3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
      a. Dosage and mixing is personally overseen by concrete supplier's trained technologist and admixtures supplier's representative.
      b. Adequate mixing time is provided after addition of admixtures.
      c. The maximum time to placement of concrete remains 90 minutes after water is added to the mix - not 90 minutes after any field additions/adjustments.
      d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

D. Conveying concrete:
   1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
   2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.

3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

3.05 PLACING AND CONSOLIDATING

A. Preparation:
   1. Obtain Engineer’s acceptance of completed preparations before placing concrete.
      a. Notify Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
      b. Submit completed Attachment D - Contractor’s Concrete Placement Checklist Form.
   2. Confirm completeness of the following before notification of readiness is given to Engineer:
      a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
      b. Reinforcement is secure and properly fastened in its correct position.
      c. Loose form ties at construction joints have been retightened.
      d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
      e. Forms have been cleaned of debris and form release agents are applied as specified.
   3. Preparation for placement of footings and slabs on grade:
      a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
      b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
      c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
      d. Do not place concrete if subgrade is muddy or soft.
   4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
      a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
      b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.

B. Concrete placement:
   1. Do not place concrete:
      a. With slump outside the limits specified in Table 3 of this Section.
      b. In which initial set has occurred, or that has been retempered.
      c. During rainstorms or high velocity winds.
   2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.

3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
4. Place concrete on slopes starting from bottom of slope and working upward.
5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.
6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch or more than 1 inch.
8. Placement of concrete for slabs, beams, or walkways:
    a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    b. Allow set time of not less than 1 hour for shrinkage.
        1) During waiting time, keep top surface of concrete moist, but not wet.
        2) Do not permit water to pond or stand on the surface.
        3) Do not coat surface with evaporation retarders or curing agents.
    c. Start placement above wall or column with layer of cement grout as described in the preceding paragraph.

C. Consolidating concrete:
1. Consolidate concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the Work.
3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
4. Vibrators:
    a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
    c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
7. Do not over-vibrate so as to produce segregation.

3.06 FINISHING CONCRETE

A. Provide concrete finishes in accordance with Section 03_35_29 - Tooled Concrete Finishing unless otherwise indicated on the Drawings.

B. Liquid evaporation retardant:
1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.

2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and included as Attachment A - Menzel Formula and Nomograph to this Section.
3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
4. Do not work evaporation retardant into the surface of the concrete.
5. Do not use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).

C. Concrete sealer:
1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings, and Section 03_35_29 - Tooled Concrete Finishing.

3.07 CURING

A. Cure concrete by methods specified in this Section.

B. Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 7 days after placement.
1. Provide at least 350 degree days of curing (350 degrees times 7 days of 24 hours each).
2. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.

C. Schedule of curing methods:
1. Cure the following concrete surfaces using water curing, or plastic membrane curing.
a. Floor surfaces of water containment structures.
b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
c. Surfaces where grout or other toppings will be placed over the surface.
d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed within 7 days after concrete placement.
f. Horizontal concrete surfaces at tops of walls.
2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor's option.
a. Surfaces not listed in the preceding paragraph.

D. Water curing:
   1. Keep surfaces of concrete constantly and visibly wet, day and night, for period of not less than 7 days.
      a. Each day forms remain in place will be counted as 1 day of water curing.
      b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.
   2. Begin water curing as soon as concrete attains initial set.
   3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to Engineer.
      a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during the 7-day curing period.
      b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.
   4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

E. Plastic membrane curing:
   1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.
   2. Cover entire surface of finished concrete with membrane.
   3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
   4. Fully seal joints and edges to provide full seal around perimeter.
   5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

F. Sprayed membrane curing compound:
   1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
      a. If more than 1 hour elapses after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than 7 days.
      b. Do not remove sprayed membrane curing compound from concrete in less than 7 days after initial application.
      c. When application of curing compound at concrete joints is accepted by Engineer, take care to apply curing compound to all surfaces along full profile of joints.
   2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
      a. Apply curing compound in at least 2 coats.
      b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.
      c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying.
      d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.

3. Thickness and coverage of curing compound:
    a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
    b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
4. If Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
    a. If proposed sample is not equal or better, in opinion of the Engineer, the proposed substitution will not be allowed.
5. Removal of curing compound.
    a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
    b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.
6. Prior to final acceptance of the Work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

3.08 PROTECTION

A. General:
    1. Keep forms in place, as specified in Section 03_11_07 - Concrete Formwork, to provide curing and to protect concrete surfaces and edges from damage.
    2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Loading of concrete members:
    1. Placement of loads on or against green concrete is not permitted.
    2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
        a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
        b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

3.09 HOT WEATHER CONCRETING

A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
   1. Comply with the recommendations of ACI PRC-305 and this Section.

B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan.
   1. Maintain at least 1 copy on site.
   2. Provide plan for review if requested by the Engineer.
      a. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
      b. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
      c. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by Engineer before beginning concrete placements.

C. Preparation:
   1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
      a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
      b. Do not allow water to puddle in forms or placement areas.
   2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
   3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.

D. Batching and delivery:
   1. Retarding admixtures will not be permitted.
   2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
      a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
      b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
   3. If necessary:
      a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1-to-1 ratio by weight.
      b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.

E. Placing and finishing:
   1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.
   2. Provide plastic sheeting, fog nozzles, shades, or other means to reduce concrete temperature and protect from moisture loss.

F. Protection and curing:
   1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
   2. Flatwork: Protect and cure using water curing methods as specified in this Section.
      a. Water curing:
         1) Keep concrete continuously wet and make provisions for runoff.
         2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.
   3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
      a. Cover forms and keep continuously moist for at least 24 hours after placement.
      b. Loosen forms as soon as this can be accomplished without damaging the concrete.
      c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as required by Section 01_45_00 - Quality Control.

B. Field tests:
   1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
   2. Sampling and testing shall be performed by Contractor's testing laboratory. See Section 01_45_24 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
      a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
      b. Provide full access for Engineer to observe concrete sampling and testing at any time.
      c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
      d. Provide 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to Owner's testing laboratory.
   3. Testing shall include:
      a. Sampling of concrete in accordance with ASTM C172.

b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
c. Slump of concrete using slump cone in accordance with requirements of ASTM C143. Test slump at the following intervals:
    1) At the beginning of each placement.
    2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
    4) Observe concrete during slump test for signs of segregation.
        a) Observe concrete to see if mortar or moisture flows from slumped concrete.
        b) Reject concrete if mortar or moisture flows out of mix.
d. Unit weight of concrete in accordance with ASTM C138.
e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
    1) At beginning of each placement.
    2) As often as necessary to keep entrained air within specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
    4) Test air entrainment in concrete in accordance with ASTM C173. If air entraining admixtures used for the Work require alternate testing procedures, advise the independent testing laboratory well in advance of the dates of testing, and confirm that appropriate equipment and personnel are provided for the test.
    5) Make air test at point of delivery (discharge from mixer). For pumped concrete, make air tests at point of delivery and at point where expelled after pumping for placement.
f. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
    1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 150 cubic yards of each class of concrete, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
    2) 1 cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. The 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.
    3) Retain and store “6th cylinders” (tested and untested) at testing laboratory until 56 days. Break “6th cylinder” when directed by the Engineer.
g. Provide full access for Engineer to observe concrete sampling and testing at any time.

3.11 FIELD QUALITY CONTROL BY OWNER

A. Provide on-site inspection and field quality assurance for the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Special tests and inspections: See Section 01_45_24 - Regulatory Quality Assurance.

C. Field inspections:
    1. Required inspections:
        a. Observe construction for conformance to the Contract Documents and the accepted submittals.
    2. Records of inspections:
        a. Provide record of each inspection.
        b. Submit copies to Contractor upon request.

D. Field tests:
    1. Engineer may request, at any time, additional testing to confirm that materials being delivered and placed conform to the requirements of the Contract Documents.
        a. If such additional testing shows that the material do not conform to the specified requirements, Contractor shall pay the cost of these tests.
        b. If such additional testing shows that the materials do conform to the specified requirements, Owner will pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Remove and replace or repair non-conforming and defective work.
    1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
    2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to Owner.
    3. Project schedule will not be extended based on work to address non-conforming concrete.

B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the site and replace with conforming materials at no additional cost to Owner.
    1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.
    2. Slump: Do not place concrete that does not conform to requirements for slump.
    3. Air entrainment: Do not use concrete that does not conform to requirements for percentage of entrained air.

C. Concrete not conforming to the specified requirements for compressive strength:
    1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'c in Table 3 of this Section.
    2. Strength of concrete will be considered acceptable if following conditions are satisfied.
        a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'c.
        b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.

c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
   1) 7-day strength may be considered as an indication of 28-day strength provided effects of temperature and humidity between 7 days and 28 days are taken into account.
   2) 28-day strength may be considered as indication of 56-day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

Table 6: Strength Compliance Requirements	
Minimum Specified Compressive Strength, f'c (pounds per square inch)	**Lower Bound of an Individual Compressive Strength Test (pounds per square inch)**
Less than 5,000	f'c - 500
Over 5,000	f'c - (0.10 x f'c)

3. Non-compliant strength tests.
   a. Mark non-compliant strength test reports to highlight the non-complying results, and immediately forward copies to all parties on the test report distribution list.
   b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI CODE-318. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
   c. Submit report of compressive strength testing for Engineer's review.
   d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for Engineer's review.
   e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'c, designate such concrete in affected area will be considered defective.
   f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

D. Concrete sections or surfaces with honeycombing and voids:
   1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
   2. Do not patch, repair, or cover defective Work without prior inspection by the Engineer.
   3. Preparation of concrete for repair:
      a. Make no repair until Engineer has accepted methods for preparing surfaces and for making and curing repairs.
      b. Chip out and key-in imperfections in the Work to make them ready for repair.

c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
    1) Epoxy bonding agent as specified in Section 03_63_01 – Epoxies.
    2) Epoxy resin/Portland cement bonding agent as specified in Section 03_63_02 - Epoxy Resin/Portland Cement Bonding Agent.

4. Methods of repair:
    a. Dry pack mortar method:
        1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
        2) Smooth Holes: Clean and roughen by heavy sandblasting before repair.
        3) Install dry-pack mortar as specified in Section 03_60_00 - Grouting.
    b. Cement mortar method:
        1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
        2) Install cement mortar as specified in Section 03_60_00 - Grouting.
    c. Concrete replacement:
        1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
        2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.

E. Leaking construction joints and cracks in concrete walls and slabs:
    1. Repair cracks that develop in walls or slabs, and repair cracks that show any signs of leakage until all leakage is stopped.
    2. Pressure inject visible cracks in the following areas, other than hairline cracks and crazing, with repair products and methods acceptable to the Engineer.
        a. Floors and walls of water bearing structures.
        b. Walls and overhead slabs of passageways and occupied spaces where the opposite face of the member is exposed to weather or may be washed down and where the opposite face does not receive a separate waterproofing membrane.
        c. Other items not specified to receive separate waterproofing membrane including slabs over water channels, wet wells, reservoirs, and other similar surfaces.
    3. Continue pressure injection of cracks as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

F. Leaking expansion joints in concrete walls or slabs that include waterstops:
    1. Repair any signs of leakage until all leakage is stopped.
    2. Continue pressure injection along joints lines as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

G. Walls and slabs at overhead channels that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy.
   1. Seal on water or weather side by coating using surface-applied sealing system as specified in this Section.
   2. Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface-applied sealing system until the sweating or leaks stop.
   3. Continue application of surface-applied sealing system until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion, or date of final repair, whichever occurs later in time.

END OF SECTION

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

MENZEL FORMULA AND NOMOGRAPH

Source: ACI PRC-350

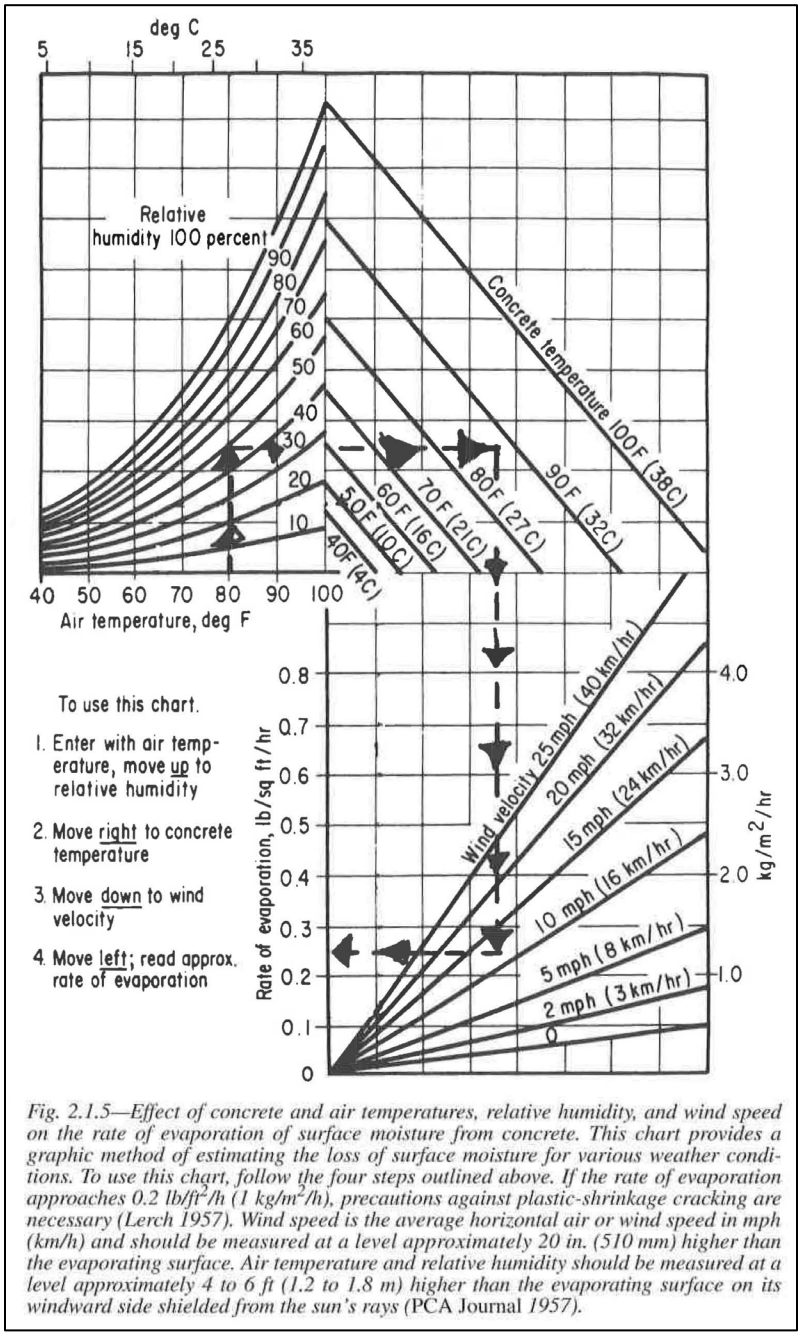


Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/h (1 kg/m²/h), precautions against plastic-shrinkage cracking are necessary (Lerch 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (PCA Journal *1957*).

ATTACHMENT B - COARSENESS FACTOR CHART

COARSENESS FACTOR CHART

Source: ACI PRC-302.1-15, Figure 8.9.2.2.

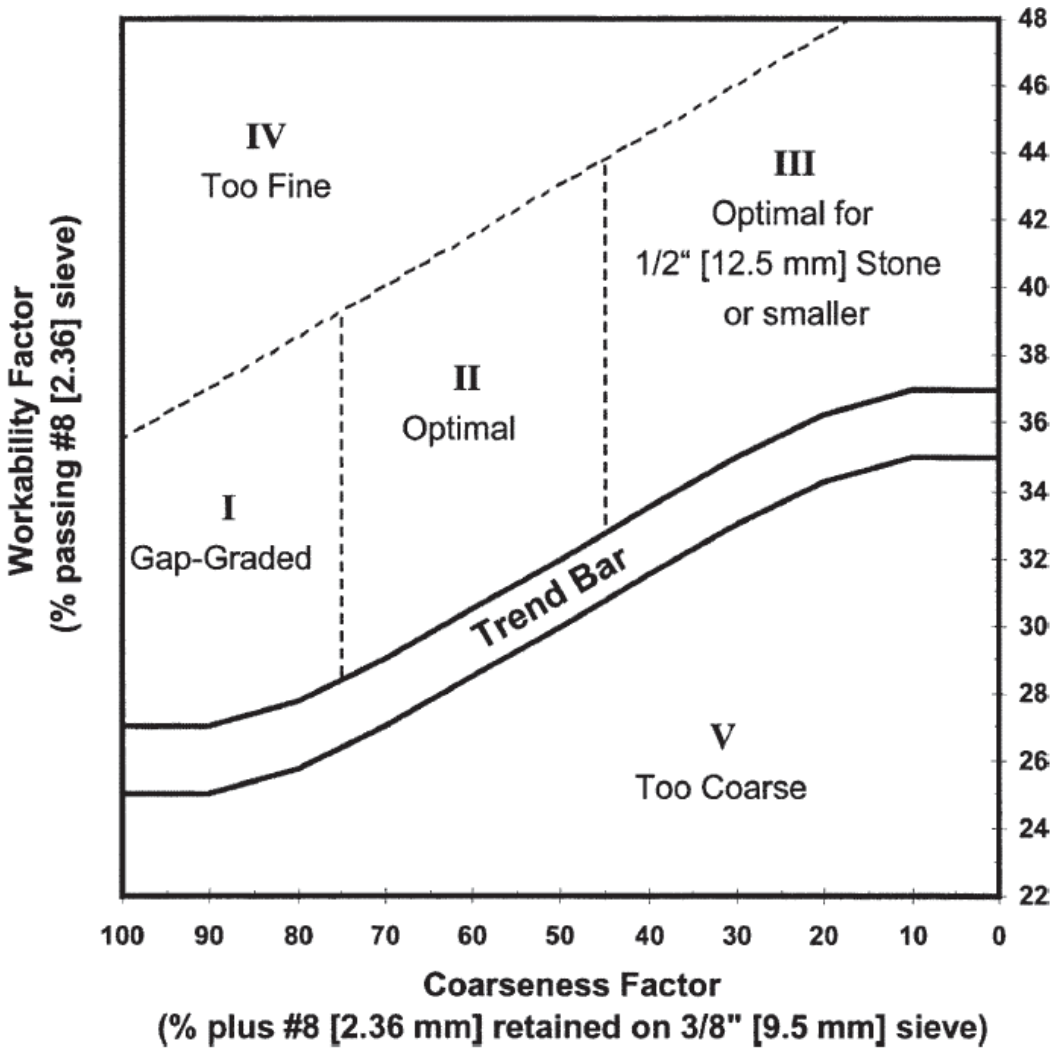
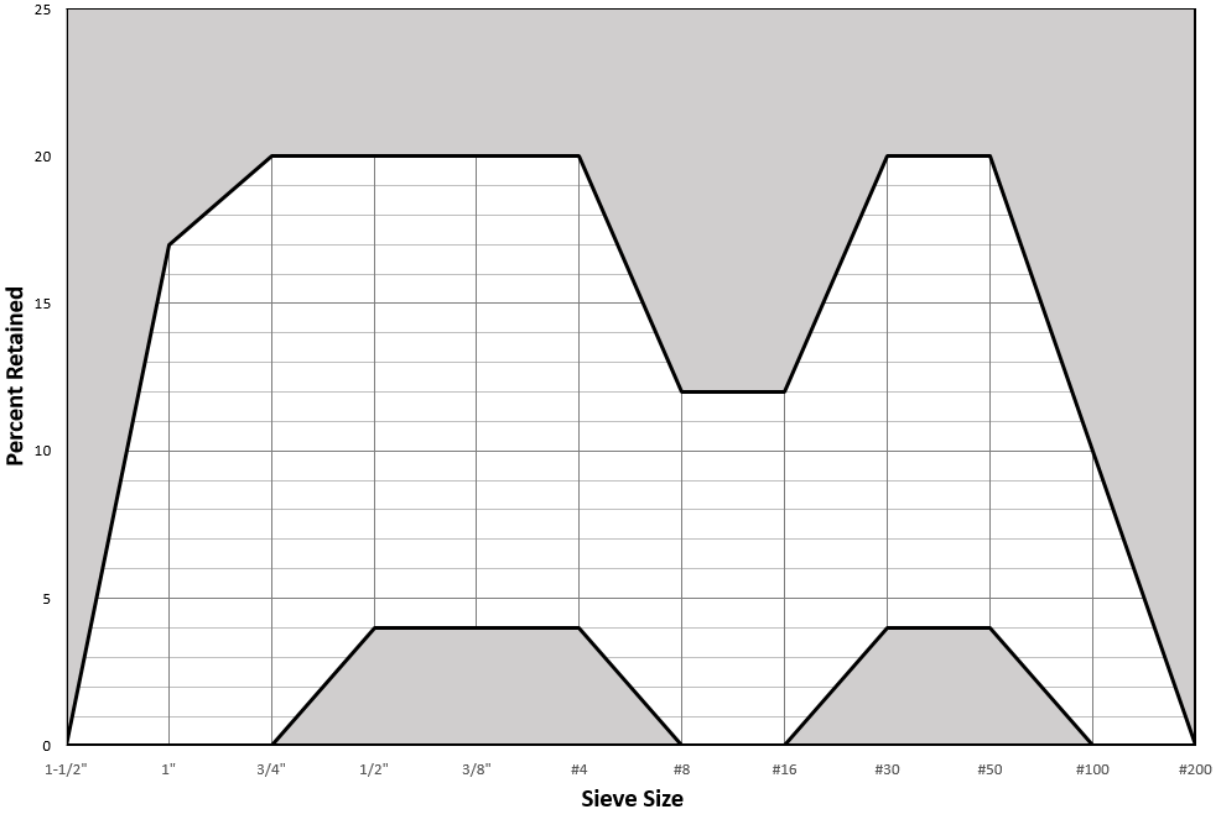


Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

COMBINED AGGREGATE GRADATION CHART



ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete: _____
Project No.: _____ Test Cylinders Taken? Yes: _____ No: _____

Preparation Slab	Contractor	N/A
Compaction Subgrade		
Filter Fabric/Drain Rock-ABC/Separator Fabric		
Drain Rock, Pea Gravel & Void Form		
Starter Wall Forms		
Reinforcing Steel		
Screeds		

Embedded Items	Contractor	N/A
A. Anchor Bolts		
B. Water Stop		
C. Rebar		
D. Electrical		
E. Plumbing Rough-in		
F. Mechanical		
G. HVAC		

Concrete Placement Equip.	Contractor	N/A
A. Crane		
B. Buckets		
C. Hoppers		
D. Vibrators		
E. Elephant trunks		
F. Floodlights		
G. Pump Truck		

Building Department Notification	
Date:	Time:

Prep Wall Concrete	Contractor	N/A
Access To Work		
Ladders Secured		
Clean up and Washed Out		
Reinforcing Steel		

Forms	Contractor	N/A
A. Alignment & Grade		
B. Scaffolding		
C. Sleeves & Wall Castings		
D. Embedded Items		
E. Electrical		
F. Plumbing Rough-in		
G. Piping		

Record of Curing Conditions During Placement	
	Start: Finish:
Date:	
Time:	
Weather:	
Temperature:	
Comments:	

Location of Placement _____

The Contractor certifies the above-proposed concrete placement is prepared as indicated and is in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

SECTION 03_35_29

TOOLED CONCRETE FINISHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Tooled concrete finishes.

1.02 QUALITY ASSURANCE

A. Mock-ups:
   1. Test panels for concrete finishes:
      a. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
      b. Accepted test panels serve as standard of quality and workmanship for project.
   2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
   3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
      a. Accepted test panels serve as standard for repairs during the project.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 MIXES

A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.

2.02 CONCRETE SEALER

A. Manufacturers: One of the following or equal:
   1. Euclid Chemical Company: Diamond Hard.
   2. L&M Construction Chemicals: SealHard.

PART 3 EXECUTION

3.01 CONCRETE FINISHES

A. Cement for finishes:
   1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.

B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
   1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
   2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
   3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
   4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
      a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
      b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
      c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
      d. Do not let any material remain on surfaces, except that within pits and depressions.
      e. Wipe surfaces clean and moist cure.
   5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
      a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
      b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
      c. Rub surfaces until form marks and projections have been removed.
      d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
      e. Moist cure brushed surfaces and allow to harden for 3 days:
         1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
         2) Continue curing for remainder of specified time.
      f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.
         1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.

2) Continue stoning until surface is hard.
3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.
4) After stoning, continue curing until 7 day curing period is completed.

C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
1. S1 finish: Screeded to grade and leave without special finish.
2. S2 finish: Smooth steel trowel finish.
3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.
5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.
6. S6 finish: Roughened finish: After concrete has been screeded to grade, apply a roughened finish by use of a jitterbug roller or similar device.

D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

3.02 CONCRETE FINISH SCHEDULE

A. Finish concrete surfaces as follows:
1. F4 finish for following vertical surfaces:
a. Concrete surfaces specified or indicated to be coated or painted.
b. Concrete surfaces, interior or exterior, exposed to view.
2. Surfaces in open channels, basins, and similar structures:
a. F3 finish for vertical surfaces which are normally below water surface.
b. F4 finish for vertical surfaces located above normal water surface and exposed to view.
c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.
3. S1 finish for following surfaces:
a. Projecting footings which are to be covered with dirt.
b. Slab surfaces which are to be covered with concrete fill.
4. S2 finish for following surfaces:
a. Tops of corbels.
b. Tops of walls and beams not covered above in this Section.
c. Tops of slabs not covered above in this Section.
d. All other surfaces not specified to be finished otherwise.

5. S3 finish for following surfaces:
    a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.
6. S4 finish for following surfaces:
    a. Exterior walkways.
    b. Tops of exterior walls or beams which are to serve as walkways.
    c. Tops of exterior walls or beams which are to support gratings.
    d. Top surface of slabs for basins, channels, digesters, and similar structures.
7. S6 finish for following surfaces:
    a. Basin bottoms, or other similar slab surfaces, over which layer of basin bottom grout will be applied.

END OF SECTION

SECTION 03_41_41

PRECAST CONCRETE ROOF AND WALL PANELS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast concrete roof and wall panels.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   a. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.

B. ASTM International (ASTM):
   1. C33 – Standard Specification for Concrete Aggregates.
   2. C150 – Standard Specification for Portland Cement.
   3. C494 – Standard Specification for Chemical Admixtures for Concrete
   4. C595 – Standard Specification for Blended Hydraulic Cements.
   5. C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   6. C1077 - Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
   7. C1778 – Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code, Steel.
   2. D1.4 - Structural Welding Code, Reinforcing Steel.

D. Precast/Prestressed Concrete Institute (PCI):
   1. MNL-116 - Manual for Quality Control for Plants and Production of Structural Precast Concrete Products.
   2. MNL-124 - Design for Fire Resistance of Precast/Prestressed Concrete.
   3. MNL-127 - Standard and Guidelines for Erection of Precast Concrete Products.
   4. MNL-132 - Erection Safety for Precast and Prestressed Concrete.
   5. MNL-135 - Tolerance Manual for Precast and Prestressed Concrete Construction.
   6. TR-6 - Interim Guidelines for the Use of Self-Consolidating Concrete.

1.03 SUBMITTALS

A. Shop drawings:
   1. Shop drawings of precast showing details of roof and wall panels, reinforcing, lifting devices/embeds, center of gravity locations, location and size of openings/penetratons, joints, anchorage, connections, camber, and other information required to describe proposed materials and construction methods.
   2. Drawings showing detailing, quantity, and placement of all mild steel reinforcing.
   3. Type and detail of anchorage for tensioning prestressing steel.

B. Delegated design submittals:
   1. Concrete mix design.
      a. Mix designs shall be signed and sealed by a Civil or Structural Engineer licensed in the State of California.
      b. Submit mix designs including minimum specified compressive strength, proportions of constituent materials, water to cementitious materials ratio(s), and estimated slump of the mix.
      c. Submit materials data sheets for cement, aggregates, and admixtures. Indicate physical properties of materials and demonstrate that materials conform to the standards specified in this Section.
      d. Submit data demonstrating that concrete mix designs satisfy the requirements of ASTM C1778 for reduction of risk of aggregate-alkali reactions.
      e. Curing procedures for concrete.
   2. Calculations:
      a. Precast designs shall be signed and sealed by a Civil or Structural Engineer licensed in the State of California.
      b. Submit calculations that demonstrate the adequacy of the precast roof and wall panels to support the required loads:
         1) DL = 50 psf and LL = 150 psf.
         2) Temporary loads during manufacture, including casting, handling, transportation, and installation
         3) Ultimate axial and lateral loads.
      c. Calculations shall include signed and sealed copies of the precast shop drawings.

C. Quality control submittals:
   1. Certificates of compliance.
   2. Manufacturer's instructions.

1.04 QUALITY ASSURANCE

A. General:
   1. Design: Comply with ACI CODE-318 and the requirements of these Specifications as applicable to the types of precast concrete members required for the Work.
   2. Manufacturing: Comply with PCI MNL-116, PCI MNL-135 and the requirements of these Specifications as applicable to the types of precast concrete members provided.

3. Erection: Comply with PCI MNL-127 and the requirements of these Specifications for erection and installation of precast concrete.

B. Qualifications:
   1. General:
      a. Experience required by this Section refers to Engineering and fabrication of precast concrete products similar in materials, design, extent, and complexity to those required for this Project.
   2. Design Engineer:
      a. Individual(s) in responsible charge of design and detailing of precast and precast prestressed structural concrete members shall be a civil or structural Engineer holding a current license in the jurisdiction where the Work will be erected and experienced in providing Engineering services of the type required for this Work.
      b. Demonstrate at least 10 years recent experience in design of the types of members required for this Work.
   3. Manufacturer/Fabricator:
      a. Manufacturer shall have been engaged in manufacture of precast concrete of the types included in the Work for a minimum period of 10 years.
      b. Registered with and acceptable to the authorities having jurisdiction.
      c. Assumes responsibility for engineering design of precast concrete members, including compliance with the requirements specified in this Section. This includes responsibility for preparation of comprehensive Engineering analysis and detailing, and preparation of shop drawings for fabrication and erection.
      d. Precast concrete producer certified under the PCI Certified Plant Program and holding certification in the following product groups and categories at the time of bidding and throughout the period of production and erection of the members.
         1) Group C - Commercial (structural) products.
            a) Categories:
               (1) C1 - Precast concrete products, no prestressed reinforcement.
         2) Continuity: In the event that manufacturer's certification is revoked or lapses during production of the members, production shall immediately stop, regardless of the status of completion of contracted work. Production will not be allowed to re-start until required corrections are made and certification has been re-established.
            a) Members designed or produced within the 90 days preceding loss of certification shall be subject to investigation and testing as required by the Engineer. Such work shall be provided by an independent Engineer and or testing laboratory with costs paid by the manufacturer whose certification was lost.
            b) In the event that certification cannot be re-established in a timely manner before additional members are produced, the manufacturer shall, at no additional cost, contract manufacture of the remaining production to a plant holding current PCI certification for the group and categories specified.

e. Having sufficient production capacity to produce the required members without delaying the Work.
f. Employing at least 1 person, regularly present in the plant, who holds current certification by PCI as “Plant Quality Personnel, Level II.”

4. Testing agency:
   a. Independent accredited testing agency.
   b. Qualified in accordance with ASTM C1077 and ASTM E329 to conduct the testing specified.
5. Welders and welding procedures:
   a. Qualify welders and welding procedures in accordance with AWS D1.1, AWS D1.4, and/or AWS D1.6 as applicable for weld types, positions, and procedures required for this Work.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General:
1. Design, fabricate, and erect precast concrete members as indicated on the Drawings and specified.

B. Delegated design:
1. Design shall be performed under the direction of a professional civil or structural Engineer holding a current license in the State of California, and having at least 5 years of recent and relevant experience in the design and detailing of precast concrete members of the types required for this Work.
2. Design modifications. If modifications to the information indicated in the Contract Documents are proposed, notify the Engineer and submit written description of proposed modifications before preparing designs and shop drawings. Obtain Engineer’s acceptance of proposed changes.
   a. Do not affect appearance, durability, or strength of members.
   b. Maintain the general design concept when altering size or alignment of members.

C. Performance/design criteria:
1. Design and detail precast concrete members and connections to withstand design loads indicated, to maintain clearances at openings; to allow for fabrication and erection tolerances; to accommodate camber, and dead and live load deflections; to accommodate shrinkage and creep of members and any supporting or surrounding structure; and to allow for other movements of the structure.
2. Regulatory requirements:
   a. Comply with requirements of the building code as specified in Section 01_41_00 - Regulatory Requirements including state and local requirements.
   b. Comply with ACI CODE-318 and the requirements as specified in this Section.
   c. Where conflicts between requirements exist, the more restrictive shall apply.

3. Concrete – Precast
    a. Conforming to ACI CODE-318 except as modified in this Section.
        1) Proportioning for concrete: As required to satisfy precast requirements.
        2) Normal weight concrete unit weight:
            a) 140 pounds per cubic foot, minimum.
            b) 150 pounds per cubic foot, maximum.
        3) Maximum water-soluble chloride ion concentration: 0.06 percent by weight of cement.
        4) Mix design shall conform to ASTM C1778 for risk reduction of alkali-aggregate reactions. If the prescriptive approach is used, the following classifications shall be used:
            a) Size and Exposure Conditions: All concrete exposed to humid air, buried or immersed.
            b) Structures Classified on Basis of the Severity of Consequences: Class SC 4.
        5) Minimum compressive strength: Compressive strength shall satisfy the following requirements:
            a) Minimum strength required by precast design.
            b) Minimum strength required to satisfy durability requirements specified in this Section.
        6) Maximum water/cement ratio: As required to satisfy the durability requirements specified in this Section.
        7) Target air content: As required to satisfy the durability requirements specified in this Section.

2.02 MATERIALS

A. Portland cement: In accordance with ASTM C150 or ASTM C595, excluding Type IS (≥70) and Type IT (S≥70).

B. Supplemental Cementitious Materials:
    1. Fly ash:
        a. In accordance with ASTM C618.

C. Water:
    1. Water used for manufacture of precast concrete: Potable from municipal water source.

D. Aggregates:
    1. Aggregate shall be non reactive. (Classified as Aggregate Reactivity Class R0 in accordance with ASTM C1778.)
    2. Conform to the requirements of ASTM C33. Incorporate the maximum coarse aggregate size that satisfies member thickness and clearance requirements of ACI CODE-318 to minimize volume of cement paste and reduce shrinkage.
    3. Coarse aggregate weathering classification: 4S in accordance with ASTM C33.

E. Admixtures Included in precast concrete mixes at manufacturer's option.:
   1. Where required, water reducing admixture in accordance with Type A of ASTM C494 may be used.
   2. Admixtures containing chlorides shall not be used.

F. Reinforcement support chairs: Stainless steel.

G. Parting compound: Suitable for intended use, as standard with manufacturer.

2.03 ACCESSORIES

A. Lifting inserts, lifting brackets, and swivel lift plates:
   1. Lifting inserts: Have minimum factor of safety of 3 at worst possible working condition.
   2. Lifting brackets or swivel lift plates: Type that prevent excessive local moment in precast panel at point of pickup when panel is hanging vertically.

2.04 FABRICATION

A. Shop assembly:
   1. Forms:
      a. Make forms watertight, accurate, and true to measurement as indicated on the Drawings.
      b. Thoroughly clean forms before each usage and coat contact surface thoroughly with form release compound so that no bond occurs between concrete and form.
      c. Avoid casting panels over surfaces with irregularities or joints, where practical.
   2. Casting on top previously cast panels:
      a. If subsequent panels are cast on top of previously cast panels, allow no less than 2 days to elapse between time panel is finished until work is performed on surface of panel.
      b. For columns and similar shapes where workmen do not have to get onto finish surface, placing of form release compound and reinforcement may begin 8 hours after completion of finishing.
   3. Curing: Water cure precast concrete for not less than 7 days, except that after 24 hours of water curing, steam curing may be substituted at ratio of 1 hour of steam curing for 3 hours of water curing.
   4. Removal from forms: Do not remove any precast unit from forms or otherwise handled until adequate strength has been acquired, and in no case less than 24 hours after casting.
   5. Precast wall panels:
      a. Casting: Cast panels as indicated on the Drawings and as specified in this Section.
      b. Pickup points: Pickup points and reinforcement required for stresses encountered during tilting and lifting have not been indicated on the Drawings.

B. Shop finishing:
    1. Precast wall panels:
        a. After wall panels and sections are installed, rework surfaces, if necessary, to obtain smooth, uniform texture and color between panels and to obtain finish specified.
        b. The Engineer may require panel surfaces to be sandblast or "sacked" to achieve uniformity.
    2. Precast concrete roof panels:
        a. Surfaces exposed to view after installation: Receive F3 finish and be prepared for painting as specified in Section 09_91_00 - Painting.

PART 3 EXECUTION

3.01 PREPARATION

A. Preparation for lifting precast roof and wall panels:
    1. Stiffness for handling:
        a. Fit any panel lacking adequate stiffness for handling with strongbacks before the panel is lifted.
        b. Use lifting devices as specified.
        c. After panel is placed in its final position, remove strongbacks.

3.02 ERECTION

A. Precast roof and wall panels:
    1. Placing:
        a. Tilt up panels using 4 or more pickup points depending on size of panel.
        b. Use rigging such that each pickup point has same load, from time panel is horizontal until it has been tilted to vertical position.
    2. Slab lifting inserts, lifting brackets, and swivel lift plates: Use types acceptable to Engineer for lifting panels.
    3. Securing in place:
        a. Secure each panel in proper position with adequate bracing to prevent wind or other forces from dislocating panels.
        b. Leave bracing in place until after columns have been cast and roof framing and roof deck are in installed and capable of supporting panels.

3.03 ADJUSTING

A. General: Remove any precast unit cracked or otherwise structurally damaged in handling due to any cause from project site and replace with structurally sound unit.

B. Precast roof and wall panels: Patch holes in precast panels resulting from installation of strongbacks with mortar blended to match concrete.

END OF SECTION

SECTION 03_60_00

GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   6. Non-shrink epoxy grout.
   7. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material Submittals.

B. Cement mortar:
   1. Mix design.
   2. Material Submittals.

C. Non-shrink epoxy grout:
   1. Manufacturer's literature.

D. Non-shrink grout:
   1. Manufacturer's literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following or equal:
      a. Five Star Products, Inc., Five Star DP Epoxy Grout.
      b. Master Builder Solutions, MasterFlow 648.
      c. L&M Construction Chemicals, Inc., EPOGROUT.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
   6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
   7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. Master Builder Solutions, MasterFlow 928.
      c. L&M Construction Chemicals, Inc., CRYSTEX.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.

4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
5. Require only addition of potable water.
6. Water for pre-soaking, mixing, and curing: Potable water.
7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
    a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
    a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
    b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
    1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
    2. Use same materials for cement grout that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
    1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
    2. Use same materials for cement mortar that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
    4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
    1. Proportions by weight: 1 part Portland cement to 2 parts concrete sand.
        a. Portland cement: As specified in Section 03_30_00 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03_30_00 - Cast-in-Place Concrete.

D. Epoxy grout:
    1. Consist of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03_63_01 - Epoxies.
        b. Epoxy gel: As specified in Section 03_63_01 - Epoxies.
        c. Sand: Clean, bagged, graded, and kiln-dried silica sand.

2. Proportioning:
    a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.

E. Grout:
1. Mix in proportions by weight: 1 part Portland cement to 4 parts concrete sand.
    a. Portland cement: As specified in Section 03_30_00 - Cast-in-Place Concrete.
    b. Concrete sand: As specified in Section 03_30_00 - Cast-in-Place Concrete.

F. Non-shrink epoxy grout:
1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
    a. Remove loose or broken concrete.
3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
1. Cement grout:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.

3. Dry-patch mortar:
    a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
4. Non-shrink epoxy grout:
    a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
5. Non-shrink grout:
    a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    b. Do not retemper by adding more water after grout stiffens.

B. Placement:
1. Cement grout:
    a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
    b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
    a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
    a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
    b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
    a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
1. Cement based grouts and mortars:
    a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
    b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
    a. Cure grouts in accordance with manufacturers' recommendations.
        1) Do not water cure epoxy grouts.
    b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
   1. General:
      a. Use non-shrink grout as specified in this Section.
      b. Baseplate grouting shall take place from 1 side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
      c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
      d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.
   2. Forms and headboxes:
      a. Build forms using material with adequate strength to withstand placement of grouts.
      b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
      c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
      d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on 1 side of baseplate.
      e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

SECTION 03_63_01

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

1.03 SUBMITTALS

A. General: Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product Data: Submit manufacturer's data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.

C. Quality control Submittals:
   1. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations set forth by manufacturer.
   3. Perform and conduct work of this Section in neat orderly manner.

2.02 MATERIALS

A. General:
   1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II, and IV; Grade 1; Class C, except as modified in this Section.
   1. Manufacturers: One of the following or equal:
      a. Master Builders Solutions, MasterInject 1380.
      b. Dayton Superior, Unitex Pro-Poxy 100.
      c. Sika Corporation, Sikadur 35 Hi-Mod LV.
   2. Required properties:

Table 1. Material Properties - Epoxy

Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	7,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	10,000 pounds per square inch, minimum.
Bond Strength (harded concrete to harded concrete after 2-day cure)	ASTM C882	1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy.
Viscosity (mixed)		250 to 550 centipoise

Notes:

(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C.
   1. Manufacturers: One of the following or equal:
      a. Master Builders Solutions, MasterEmaco ADH 327.
      b. Dayton Superior, Sure Anchor J50.
      c. Sika Corp., Sikadur 31, Hi-Mod Gel.
   2. Required properties:

Table 2. Material Properties - Epoxy Gel

Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	2,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,000 pounds per square inch, minimum.
Bond Strength (14-day)	ASTM C882	1,500 pounds per square inch, minimum.

Notes:

(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C.
   1. Manufacturers: One of the following or equal:
      a. Master Builders Solutions, MasterEmaco ADH 326.
      b. Dayton Superior, Sure Bond J58.
      c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL.
   2. Required properties:

Table 3. Material Properties - Epoxy Bonding Agent		
Property	**Test Method**	**Required Results**
Tensile Strength (7-day)	ASTM D638	3,300 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,300 pounds per square inch, minimum.
Bond Strength (14-days)	ASTM C882	1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent.
Pot Life	-	Minimum 60 minutes at 100 degrees Fahrenheit.
Notes: (1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.		

   3. If increased contact time is required for concrete placement, epoxy resin/Portland cement bonding agent, as specified in Section 03_63_02 - Epoxy Resin/Portland Cement Bonding Agent, may be used instead of epoxy bonding agent.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03_63_02

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a water solution of a polyamine.
3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
   4. Bond strength in accordance with ASTM C882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600 pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 05_05_24

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
      b. Anchor rods.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
   3. Appurtenances for anchoring and fastening:
      a. Anchor bolt sleeves.
      b. Isolating sleeves and washers.
      c. Thread coating for threaded stainless steel fasteners.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   6. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   7. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.

9. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
10. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
11. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
12. F436 - Standard Specification for Hardened Steel Washers.
13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
14. F594 - Standard Specification for Stainless Steel Nuts.
15. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
16. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Built-In Anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-In Anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead Installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-Installed Anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
    a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
    b. Exterior and interior locations at the following treatment structures:
        1) Wastewater treatment facilities: Liquids stream:
            a) UV disinfection treatment.
2. Wet and moist locations: Describes locations, other than "corrosive locations," that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
    a. Exterior portions of buildings and structures.

b. Liquid-containing structures:
    1) Locations at and below the maximum operating liquid surface elevation.
    2) Locations above the maximum operating liquid surface elevation and:
        a) Below the top of the walls containing the liquid.
        b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
c. Liquid handling equipment:
    1) Bases of pumps and other equipment that handles liquids.
d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
e. Other locations indicated on the Drawings.

3. Other locations:
    a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 SUBMITTALS

A. General:
1. Submit as specified in Section 01_33_00 - Submittal Procedures.
2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
1. Product data:
    a. Cast-in anchors:
        1) Manufacturer’s data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    b. Post-installed anchors:
        1) For each anchor type, manufacturer’s data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
2. Samples:
    a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
3. Certificates:
    a. Cast-in anchors:
        1) Mill certificates for steel anchors that will be supplied to the site.
    b. Post-installed anchors:
        1) Manufacturer’s statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.
4. Test reports:
    a. Post-installed anchors: For each anchor type used for the Work:
        1) Current ICC-ES Report (ESR) demonstrating:
            a) Acceptance of that anchor for use under the building code specified in Section 01_41_00 - Regulatory Requirements.

b) That testing of the concrete anchor included the simulated seismic tension and shear tests of AC193, and that the anchor is accepted for use in Seismic Design Categories C, D, E, or F and with cracked concrete.

5. Manufacturer's instructions:
   a. Requirements for storage and handling.
   b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
   c. Requirements for inspection or observation during installation.
6. Qualification statements:
   a. Post-installed anchors: Installer qualifications:
      1) Submit list of personnel performing installations and include date of manufacturer's training for each.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Post installed anchors shall be in accordance with building code specified in Section 01_41_00 - Regulatory Requirements.
   2. Installers: Post-installed mechanical anchors:
      a. Conduct a training session with the manufacturer's authorized technical representative for the project on-site:
         1) Use only trained and qualified personnel for anchor installation.
      b. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.

B. Special inspection:
   1. Provide special inspection of post-installed anchors as specified in Section 01_45_24 - Regulatory Quality Assurance and this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

1.07 PROJECT CONDITIONS

A. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
      b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
         1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.
   2. Materials:
      a. Ship anchor bolts with properly fitting nuts attached.
      b. Type 316 stainless steel:
         1) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
         2) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         3) Washers: Type 316 stainless steel.
      c. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM F2329.
         2) Bolt: ASTM F1554, Grade 36, heavy hex, coarse thread.
         3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
         4) Washers: ASTM F436, Type 1.

B. Anchor rods:
    1. Description: Straight steel rod having threads on each end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
    2. Materials:
        a. Stainless steel: Type 316:
            1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
            2) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
            3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
            4) Washers: Type 316 stainless steel.
            5) Plates (embedded): ASTM A240.

C. Steel plates or shapes for fabrications including assemblies with welded studs or deformed bar anchors:
    1. Stainless steel: Type 316L or Type 304L:
        a. Plates (embedded): ASTM A240.
    2. Galvanized steel:
        a. Hot dip galvanized in accordance with ASTM A123.
        b. Steel: ASTM A36.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
    1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01_41_00 - Regulatory Requirements. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
        1) In regions of concrete where cracking has occurred or may occur.
        2) To resist short-term loads due to wind forces.
        3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.
    2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
        a. Calculations shall be prepared by and shall bear the signature and seal of a Civil or Structural Engineer licensed in the State of California.
        b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
   2. Concrete anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
      b. Manufacturers: One of the following or equal:
         1) Hilti, Kwik Bolt TZ Expansion Anchor.
         2) DEWALT/Powers, PowerStud.
         3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
      c. Materials. Integrally threaded stud, wedge, washer, and nut:
         1) Stainless steel: Type 316.
         2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

2.05 APPURTENANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
   1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
   2. Plastic sleeves:
      a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
      b. Manufacturers: The following or equal:
         1) Portland Bolt & Manufacturing Co.

B. Isolating sleeves and washers:
   1. Manufacturers: One of the following or equal:
      a. Central Plastics Co.
      b. Allied Corrosion Industries.
   2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
   3. One sleeve required for each bolt.
   4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
      a. Proper size to fit bolts.
      b. Two 1/8-inch thick steel washers for each bolt.

c. G3 Phenolic: 2 insulating washers are required for each bolt:
    1) Thickness: 1/8 inch.
    2) Base material: Glass.
    3) Resin: Phenolic.
    4) Water absorption: 2 percent.
    5) Hardness (Rockwell): 100.
    6) Dielectric strength: 450 volts per mil.
    7) Compression strength: 50,000 pounds per square inch.
    8) Tensile strength: 20,000 pounds per square inch.
    9) Maximum operating temperature: 350 degrees Fahrenheit.

C. Coating for repair of galvanized surfaces:
    1. Manufacturers: The following or equal:
        a. Jelt, Galvinox.

D. Thread coating: For use with threaded stainless steel fasteners:
    1. Manufacturers: One of the following or equal:
        a. Bostik, Never-Seez.
        b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
    1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
    2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
    1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
    2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors.
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Seal top of sleeve to prevent grout from filling sleeve.
   3. Anchor rods.
   4. Install as specified for anchor bolts.

3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS

A. General:
   1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.
   2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
   3. After anchors have been positioned and inserted into concrete or masonry, do not:
      a. Remove and reuse/reinstall anchors.
      b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:
   1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).
   2. Accurately locate holes:
      a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
      b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
   3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
      a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
   4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
   5. Drill using anchor manufacturer's recommended equipment and procedures:
      a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
         1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
         2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
   6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
   7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
      a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
      b. Repeat cleaning process as required by the manufacturer's installation instructions.
      c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
   1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	**Minimum Effective Embedment Length**		**Minimum Member Thickness**
	In Concrete	**In Grouted Masonry**	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

E. Flush shell anchors:
   1. Flush shell anchors are not permitted in the Work.
   2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.

3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.07 FIELD QUALITY ASSURANCE

A. Owner's Representative will provide on-site observation and field quality assurance for the Work of this Section.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to Engineer upon request.
   3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
   1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
      a. Anchor bolts.
      b. Anchor rods.
   2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
      a. Anchor:
         1) Type and dimensions.
         2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
         3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
         4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
   3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
      a. Base material (concrete or grouted masonry):
         1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
         2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
   2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
      a. Provide continuous special inspection for post-installed anchors in "overhead installations" as defined in this Section.

3. Requirements for periodic special inspection:
    a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
        1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new “initial inspection.”
    b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
    c. Anchor:
        1) Manufacturer, type, and dimensions (diameter and length).
        2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
    d. Hole:
        1) Positioning: Spacing and edge distances.
        2) Drill bit type and diameter.
        3) Diameter, and depth.
        4) Hole cleaned in accordance with manufacturer’s required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
        5) Anchor’s minimum effective embedment.
        6) Anchor tightening/installation torque.
4. Requirements for continuous special inspection:
    a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
1. Owner’s Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
    a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.08 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations as specified in Section using high-strength, non-shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at the following locations:
   1. “Corrosive locations” as defined in this Section: Type 316 stainless steel.
   2. “Wet and moist locations” as defined in this Section: Type 316 stainless steel.
   3. “Other locations:”
      a. For connecting steel members to concrete or masonry: Type 304 stainless steel.
   4. At locations indicated on the Drawings.

END OF SECTION

SECTION 05_12_00

STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners and structural hardware:
      a. All thread rods.
      b. High-strength bolts.
   3. Welding.
   4. Bolting.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
   2. 360 - Specification for Structural Steel Buildings.

B. American Iron and Steel Institute (AISI):
   1. Steel alloys (“types”) as indicated.

C. American Welding Society (AWS):
   1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
   2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
   3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
   4. D1.1 - Structural Welding Code - Steel.

D. ASTM International (ASTM):
   1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A489 - Standard Specification for Carbon Steel Lifting Eyes.
   8. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   9. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

10. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
11. A992 - Standard Specification for Structural Steel Shapes.
12. B695 – Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
13. F436 - Standard Specification for Hardened Steel Washers.
14. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
15. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength.
16. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
17. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. Research Council on Structural Connections (RCSC):
   1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

1.03 DEFINITIONS

A. Snugtight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

1.04 SUBMITTALS

A. Product data:
   1. Welding electrodes for field welds: Electrode manufacturer's data.
   2. Compressible-washer-type direct tension indicators: Manufacturer’s detailed installation instructions including:
      a. Requirements for type and frequency of pre-installation verification.
      b. Requirements for coordination with regular washers.
      c. Instructions for assembling and tightening the joint so that work progresses from the most rigid part until the connected plies are in firm contact.

B. Shop drawings:
   1. Fabrication and erection drawings.

C. Quality control submittals:
   1. Welding procedure specifications (WPS) in accordance with AWS D1.1.
      a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
         1) State electrode manufacturer and specific electrodes used.
         2) Indicate required AWS qualification for joint.
      b. Submit WPS with shop drawings that indicate those welds.
      c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 for welding procedures qualified by testing.

2. Welder qualifications: For each welding process and position:
    a. Welder's qualification certificates.
    b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1.
3. Steel fabricator's AISC certification.

D. Test reports:
1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

A. Certification:
1. Steel fabricators shall be certified by the AISC or other certification acceptable to the Engineer and the building official having jurisdiction.

B. Welding:
1. Perform welding of structural metals in accordance with AWS D1.1 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
2. Make Welding Procedure Specifications available at the locations where welding is performed.
3. Notify Engineer at least 24 hours before starting shop or field welding.
4. Engineer may check materials, equipment, and qualifications of welders.
5. Remove welders performing unsatisfactory Work, or require requalification.
6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
7. Contractor shall bear costs of retests on defective welds.
8. Contractor shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Carbon Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A36	--
Rolled W and WT shapes	A992	Grade 50
Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports)	A500	Grade C
Stainless steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
* Use Type 304L (low-carbon stainless steel) if material will be welded.		
** Use Type 316L (low carbon stainless steel) if material will be welded.		

2.02 FASTENERS AND STRUCTURAL HARDWARE

A. General:
   1. Materials: Of domestic manufacture.
   2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

B. All thread rods:
   1. Carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
      b. Nuts: ASTM A194.
      c. Washers: ASTM F436.
   2. Galvanized carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
      b. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
      c. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.
   3. Stainless steel:
      a. Units descaled, pickled, and passivated as specified in “Fabrication” in this Section.

b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
c. Alloy Type 304 or Type 316 as indicated on the Drawings.
d. Type 316:
1) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
3) Washers: Type 316 stainless steel.

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

D. High-strength bolts:
1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
2. Carbon steel - Uncoated:
a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1.
b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
c. Washers:
1) Adjacent to normal, oversized, and short-slotted holes: Circular, square, or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.
d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1.
2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852.
3. Carbon steel - Galvanized:
a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM F3125, Grade A325 and the RCSC Specification.
b. Bolts, nuts, and washers: Hot-dip galvanized in accordance with ASTM F2329.
c. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1 and galvanized as specified.
d. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A563, Supplementary Requirement S1 to minimize galling.

e. Washers:
    1) Adjacent to normal, oversized, and short-slotted holes: Circular, square, or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1 and galvanized as specified. Flat circular washers unless otherwise indicated on the Drawings.
    2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel conforming to ASTM A36, and galvanized in accordance with ASTM A123.
f. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
    1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1, with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
    2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 with mechanically deposited zinc coating conforming to ASTM B695, Class 55.

2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.04 GALVANIZED SURFACE REPAIR

A. Manufacturers: The following or equal:
    1. Jelt, Galvinox.

2.05 SUPPLEMENTARY PARTS

A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.06 FABRICATION

A. Shop assembly:
    1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
    2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
    3. Round off sharp and hazardous projections and grind smooth.
    4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
    5. Take responsibility for correct fitting of metalwork.
    6. Welded connections:
        a. Comply with AWS requirements for the metals to be welded.
        b. Weld only in accordance with approved Welding Procedure Specifications.
        c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.

B. Galvanized carbon steel:
   1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123.
   2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
   3. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

A. General:
   1. Fabricate structural and foundry items to true dimensions without warp or twist.
   2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
   3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
   4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
   5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
   6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
   7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
   9. Round off sharp or hazardous projections and grind smooth.
   10. Paint or coat steel items as specified in Sections 09_96_01 – High -Performance Coatings.

B. Welding: General:
   1. Make welds full penetration type, unless otherwise indicated on the Drawings.
   2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

C. Welding: Carbon steel:
   1. General: In accordance with AWS D1.1:
      a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes.
      b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

D. Interface with other products:
   1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Fasteners: General:
   1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
   2. Anchor bolts and anchor rods: Install as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snugtight" condition.
   3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

F. Fasteners: High-strength carbon steel bolts:
   1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
   2. Provide slip-critical joints at bolted connections.
   2. Joints: Slip-critical.
      a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
      b. Furnish hardened flat washers in accordance with ASTM F436:
         1) On outer plies with slotted holes.
         2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
         3) Under element, nut, or bolt head, turned in tightening.
      c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
      d. Tighten bolts to full pretension.

3.03 FIELD QUALITY CONTROL

A. Provide quality control as specified in Section 01_45_00 - Quality Control.

3.04 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01_45_00 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.

END OF SECTION

SECTION 05_14_05

STRUCTURAL ALUMINUM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
   2. D1.2 - Structural Welding Code - Aluminum.

B. ASTM International (ASTM):
   1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

1.03 SUBMITTALS

A. Quality control Submittals:
   1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
   2. Welder’s certificates.

1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
   2. Notify Engineer 24 hours minimum before starting shop or field welding.
   3. Engineer may check materials, equipment, and qualifications of welders.
   4. Remove welders performing unsatisfactory work or require to requalify.
   5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
   6. Contractor shall bear costs of retests on defective welds.
   7. Contractor shall bear costs in connection with qualifying welders.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.

B. Structural aluminum: ASTM B308, Alloy 6061-T6.

C. Extruded aluminum: ASTM B221, Alloy 6063-T42.

D. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Miscellaneous materials:
   1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
   2. Size, form, attachment, and location shall conform to the best of current practice.
   3. In accordance with applicable ASTM Standards for materials not otherwise specified.

2.02 FABRICATION

A. Aluminum layout:
   1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
   2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.

B. Cutting aluminum:
   1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
   2. Material more than 1/2-inch thick: Saw or rout.
   3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
   4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
   5. Do not flame cut aluminum alloys.
   6. Punch or drill rivet or bolt holes to finished size before assembly:
      a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
      b. Make holes cylindrical and perpendicular to principal surface.
      c. Do not permit holes to drift in a manner to distort metal.

C. Aluminum forming and assembly:
   1. Do not heat structural aluminum, except as follows:
      a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
      b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.

D. Before assembly, remove chips lodged between contacting surfaces.

E. Welding aluminum:
   1. Perform welding of aluminum in accordance with AWS D1.2.
   2. Weld aluminum in accordance with the following:
      a. Preparation:
         1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
         2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
         3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
         4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
      b. Filler metal: Aluminum alloys in accordance with AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
      e. Do not use welding process that requires use of a welding flux.
      f. Neatly make welded closures.
      g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
      h. Make welds full penetration welds unless otherwise indicated on the Drawings.

2.03 FINISHES

A. Coating for Aluminum in contact with concrete or masonry:
   1. Epoxy mastic:
      a. Manufacturers: One of the following or equal:
         1) Carboline, Carbomastic 15.
         2) International Paint, Bar-Rust 231.
         3) Tnemec, Series 135.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION

A. Install structural aluminum products as indicated on the Drawings and specified.

B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.

C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.

D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.

E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.

F. Interface with other products:
   1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09_96_01 - High-Performance Coatings.

END OF SECTION

SECTION 05_50_00

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Handrails and guardrails.
   2. Metal gratings.
   3. Metal tread plate.
   4. Miscellaneous metals.
   5. Associated accessories to the above items.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish.
      a. M12-C22-A41.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
   10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
   13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   14. A992 - Standard Specification for Structural Steel Shapes.

15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. National Association of Architectural Metal Manufacturers (NAAMM):
1. Metal Finishes Manual.

F. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

A. Product Data:
1. Handrails and guardrails.
2. Metal grating.

B. Shop drawings:
1. Handrails and guardrails:
   a. Including details on connection attachments, gates, kick plates, ladders, and angles.
   b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
   c. Include erection drawings, elevations, and details where applicable.
   d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
2. Ladders.
3. Metal grating.
4. Metal tread plate.
5. Aluminum grating planks.
6. Stairs.
7. Miscellaneous metals.

C. Samples:
   1. Guardrails with specified finishes.

D. Quality control submittals:
   1. Design data.
   2. Test reports:
      a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
      b. Gratings:
         1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
         2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A36	--
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Stainless Steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

A. Handrails and guardrails:
   1. General:
      a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
      b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
         1) Indicate on the shop drawings locations of such equipment.
         2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.
   2. Aluminum handrails and guardrails (nonwelded pipe):
      a. Rails, posts, and fitting-assembly spacers:
         1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
      b. Kick plates: 6061 or 6105 aluminum alloy.
      c. Fastenings and fasteners: As recommended or furnished by the manufacturer.

d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
    1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
        a) Bases: 6061 or 6063 extruded aluminum alloy.
    2) Plug screws or blind rivets: Type 305 stainless steel.
        a) Other parts: Type 300 series stainless steel.
e. Finish of aluminum components:
    1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    2) Pretreat aluminum for cleaning and removing markings before anodizing.
f. Fabrication and assembly:
    1) Fabricate posts in single, unspliced pipe length.
    2) Perform without welding.
    3) Do not epoxy bond the parts.
    4) Maximum clear opening between assembled railing components as indicated on the Drawings.
g. Manufacturers: One of the following or equal:
    1) Moultrie Manufacturing Co., Wesrail.
    2) Golden Railings, Riveted System.
    3) Craneveyor Corp. Enerco Metals, C-V Rail.

3. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

B. Metal gratings:
1. General:
    a. Fabricate grating to cover areas indicated on the Drawings.
    b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    d. Band ends of grating and edges of cutouts in grating:
        1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
        2) Cutout banding: Full-height of grating.
        3) Use banding of same material as grating.
        4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
        5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
        6) Openings smaller than 6 inches: Locate opening at edge of single panel.
        7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
        8) Fabricate steel grating sections in units weighing not more than 50 pounds each.

9) Fabricate aluminum grating sections in units of weighing not more than 50 pounds each.
10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.

e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
1) Furnish a suitable dial gauge for measuring deflections.

f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.

g. Provide flush pick points for grating planks (and grating if applicable) symmetric to the plank center of gravity with the intent for the plank to be stable when two pick points are in use. Location of pick points to be suggested by fabricator and approved through shop drawing submittal(s).
1) For grating planks less than or equal to 72 inches in length, provide minimum of two pick points spaces approximately 36 inches apart (final locations to be determined and submitted by the fabricator) oriented to permit lifting by a single person standing over the center of the plank.
2) For grating planks greater than 72 inches in length, provide points identified above and a minimum of two additional pick points within 12 inches of the ends of the planks (final locations to be determined and submitted by the fabricator).
3) Provide four lifting devices compatible with each type of fabricated pick points. Lifting devices to be minimum of 30-inches long and submitted with grating plank shop drawings.

h. Irregular grating plank shapes shall include recessed handles at locations permitting access and lifting by two persons, minimum four handles per irregular section.

2. Aluminum grating:
a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
f. Maximum fiber stress for design load: 12,000 pounds per square inch.
g. Maximum deflection due to design load: 1/240 of grating clear span.
h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
i. Minimum grating height: 1-1/2 inches.
j. Manufacturers: The following or equal:
1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.

3. Heavy-duty steel grating:
a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
b. Hot-dip galvanized after fabrication in accordance with ASTM A123.

c. Manufacturers: One of the following or equal:
1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
2) Seidelhuber Metal Products, Inc., equivalent product.

4. Aluminum grating planks:
a. Materials: Meet requirements previously specified for aluminum grating.
b. Fabrication:
1) Meet requirements previously specified for aluminum grating.
c. Have unpunched surface with cross hatched anti-skid surface.
d. Minimum weight of 3-1/4 pounds per square foot.
e. Provide 1 inch diameter hole with smooth edges at each end for each plank.
f. Manufacturers: The following or equal:
1) Harsco Industrial IKG, Heavy Duty Aluminum Plank Grating HD-P.
g. Planks shall not lock with adjacent planks allowing the removal of individual planks without disturbing the adjacent planks.

C. Metal tread plate:
1. Plate having a raised figured pattern on 1 surface to provide improved traction.

D. Miscellaneous aluminum:
1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
2. Do not weld or flame cut.

E. Miscellaneous cast iron:
1. General:
a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

F. Miscellaneous stainless steel:
1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
a. Fabricate and install in accordance with the best practices of the trade.
2. Cleaning and passivation:
a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.

d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
    1) Passivation by citric acid treatment is not allowed.
        a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
    2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
    3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
e. After cleaning, inspect using methods specified for “gross inspection” in ASTM A380.
f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.

G. Miscellaneous structural steel:
    1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
        a. Fabricate and install in accordance with the best practices of the trade.

H. Isolating sleeves and washers:
    1. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
    1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
    2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. General:
    1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
    2. Interface between materials:
        a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
            1) Make application so that the isolating or protective barrier is not visible in the completed construction.
            2) Isolating sleeves and washers: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09_96_01 - High Performance Coatings.
c. Aluminum in contact with concrete or masonry.

B. Handrails and guardrails:
1. General:
a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
d. Space attachment brackets as indicated in the manufacturer's instructions.
2. Aluminum pipe handrails and guardrails:
a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
c. Discontinue handrails and guardrails at lighting fixtures.
d. Provide 1/8-inch diameter weep hole at base of each post.
e. Space posts as indicated on the Drawings.
f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
g. Space rails as indicated on the Drawings.
h. Make adequate provision for expansion and contraction of kick plates and rails.
1) Make provisions for removable sections where indicated on the Drawings.
i. Make lower rails a single, unspliced length between posts, or continuous.
j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
k. Draw up fasteners tight with hand wrench or screw driver.
l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.
p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

C. Metal gratings:
   1. General:
      a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
      b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
      c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
      d. Install angle stops at ends of grating.
      e. Installed grating shall not slide out of rebate or off support.
      f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
      g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
   2. Aluminum grating:
      a. Aluminum grating: Support on aluminum shelf angles or rebates.
   3. Aluminum grating planks:
      a. Support and install planks as specified for aluminum grating.

END OF SECTION

SECTION 07_92_00

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.

b. Break bond of sealant at bottom of joint.
c. Provide proper shape of sealant bead.
d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
1. Manufacturers: One of the following or equal:
a. Tremco, Tremflex 834.
b. Pecora Corp., Number AC-20.
c. Sonneborn, Sonolac.

2.03 PRECAST CONCRETE JOINT SEALANT

A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
1. Manufacturers: One of the following or equal.
a. Henry Corp., Ram-Nek.
b. Concrete Sealants Division, ConSeal.

2.04 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
1. Manufacturers: One of the following or equal:
a. Tremco, Proglaze.
b. Pecora Corp., Number 864.
c. Dow Corning, Number 795.
d. General Electric, Number 1200 Series.

2.05 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
1. Sika Corporation, Sikaflex 2c NS or SL
2. Sika Corporation, Sikaflex 2c NS EZ Mix.
3. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
1. Base: Polyurethane rubber.
2. Application time: Minimum 2 hours.
3. Cure time: Maximum 3 days.
4. Tack free time: Maximum 24 hours.
5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.

7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:
      a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.

3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
5. Complete caulking prior to painting.
6. Verify that concrete is thoroughly cured prior to caulking.
7. When filler compressible material is used, use untreated type.
8. Apply caulking with pneumatic caulking gun.
9. Use nozzles of proper shape and size for application intended.
10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.

3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
4. Joints between sheet metal flashing and trim.
5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
1. Use where indicated on the Drawings.
2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
4. Pavement joints.
5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
d. Building expansion joints: 1 test per every 500 LF of joint sealed.
e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 09_96_01

HIGH-PERFORMANCE COATINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
   2. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
   3. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
   4. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
   5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
   6. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
   7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
   8. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
   9. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
   10. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
   11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
   12. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
   13. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
   14. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
   15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
   16. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

B. International Concrete Repair Institute (ICRI):
   1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

C. NACE International (NACE):
   1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

D. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Occupational Safety and Health Administration (OSHA).

G. Society of Protective Coatings (SSPC):
   1. Glossary - SSPC Protective Coatings Glossary.
   2. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
   4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   6. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   8. SP 1 - Solvent Cleaning.
   9. SP 3 - Power Tool Cleaning.
   10. SP 5 - White Metal Blast Cleaning.
   11. SP 10 - Near-White Metal Blast Cleaning.
   12. SP 11 – Power Tools Cleaning to Bare Metal.
   13. SP 13 - Surface Preparation of Concrete.
   14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   15. SP COM - Surface Preparation Commentary.
   16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
   18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
   19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
   20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

1.03 DEFINITIONS

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. Specific definitions:
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. Anchor Pattern: Profile or texture of prepared surface(s).
   4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.

5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
9. Drying Time: Time interval between application and material curing.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light ouch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high-pressure water jet surface preparation.
22. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
24. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
25. Mil: 0.001 inch.
26. Overspray: Dry spray, particularly paint bonded to an unintended surface.
27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.

30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 ABBREVIATIONS

A. CSM - Coating System Manufacturer.

B. CMU - Concrete Masonry Units.

C. CSA - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.

D. CTR - Coating System Manufacturer's Technical Representative.

E. DFT - Dry-Film Thickness. Thickness of cured film, usually expressed in mils (0.001 inch).

F. SSD - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

G. TPC - Technical Practice Committee.

H. VOC - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.

I. WFT - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

1.05 SUBMITTALS

A. As specified in Section 01_33_00 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.
   4. Product data:
      a. Physical properties of coatings, including the following:
         1) Solids content.
         2) Ingredient analysis.
         3) VOC content.
         4) Temperature resistance.
         5) Typical exposures and limitations.
         6) Manufacturer's standard color chips.
      b. Compliance with regulatory requirements:
         1) VOC limitations.
         2) Lead compounds and polychlorinated biphenyls.
         3) Abrasives and abrasive blast cleaning techniques and disposal.
         4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
         5) NSF certification of coatings for potable water supply systems.
      c. CSM's current printed recommendations and product data sheets for coating systems, including:
         1) Surface preparation recommendations.
         2) Primer type.
         3) Maximum dry and wet-mil thickness per coat and number of coats.
            a) Coating Coverage Worksheets.
         4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
         5) Curing time before submergence in liquid.
         6) Thinner to be used for each coating.
         7) Ventilation requirements.
         8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
         9) Allowable application methods.
         10) Maximum allowable substrate moisture content.
         11) Maximum shelf life.
         12) Requirements for transportation and storage.
         13) Mixing instructions.
         14) Shelf life.
         15) Material Pot life.
         16) Precautions for applications free of defects.
         17) Method of application.

18) Drying time of each coat, including prime coat.
19) Compatible prime coats.
20) Limits of ambient conditions during and after application.
21) Required protection from sun, wind, and other conditions.
22) Touch-up requirements and limitations.
23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.

d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
f. List of cleaning and thinner solutions allowed by the CSMs.
g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
h. Thick film coating systems (greater than 25 mils):
1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
2) Include detail treatment for coating system at concrete joints.
3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance submittals:
a. Quality assurance plan.
b. Qualifications of CSA, including:
1) List of Similar Projects.
a) Name and address of project.
b) Year of installation.
c) Year placed in operation.
d) Point of contact: Name and phone number.
2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
c. CSA Reports:
1) Written daily quality control inspection reports.
d. CTR Reports:
1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
2) Reports on visits to project site to observe and approve coating application procedures.
3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.06 QUALITY ASSURANCE

A. CSA qualifications:
1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.

2. SSPC-QP 1 certified.
3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
   1. Certification, one of the following:
      a. NACE Level 2 or 3 Certified Coating Inspector.
      b. SSPC Level 3 Protective Coatings Inspector.
   2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
      a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits.
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Pre-installation conference: Conduct as specified in Section 01_31_19 - Project Meetings.
   1. Coordinate Hold Point schedule.

E. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

F. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

G. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

H. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor’s responsibilities.
   2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.

3. Specially trained crews with experience applying the specified coating system coating are required for:
    a. Coating application using plural component spray equipment or other specialty equipment.
    b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
4. CTR shall specially train personnel for coating systems as specified in Attachment B - Coating Detail Sheets.
    a. CSM shall approve personnel in writing applying the coating system.
5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by Owner's or Engineer's personnel.
7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer’s personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
    a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
        1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
        2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
    b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
        1) ASTM D4262.
        2) ASTM D4263.
        3) ASTM D4417.
        4) ICRI 310.2 requirements.
        5) SSPC Surface Preparation Standards.
    c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
    d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
    f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating.
        1) Perform WFT measurements in accordance with ASTM D4414.

g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

I. Inspection at Hold Points:
   1. Conduct inspections at Hold Points during the coating system application and record the results.
   2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
   3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
   4. Hold Points shall be as follows:
      a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
      b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
      c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
      d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems.
      e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points, and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01_60_00 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
   1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations.
      a. Store flammable materials in accordance with federal, state, and local requirements.
      b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.

2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
3. Container labels shall show the following:
    a. Brand name or product title.
    b. CSM's batch number.
    c. CSM's manufacture date.
    d. CSM's name.
    e. Generic material type.
    f. Application and mixing instructions.
    g. Hazardous material identification label.
    h. Shelf life expiration date.
    i. Color.
    j. Mixing and reducing instructions.
4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.08 PROJECT CONDITIONS

A. Apply coatings to dry surfaces:
    1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section:
        a. Plaster and gypsum wallboard: 12 percent.
        b. Masonry and concrete block: 12 percent.
        c. Interior located wood: 15 percent.
        d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
        e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
    1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
    2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
    3. When ambient or surface temperature:
        a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
        b. Is less than 65 degrees Fahrenheit for clear finishes, unless manufacturer allows a lower temperature.
        c. Exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
        d. Exceeds manufacturer's recommendation.
    4. When relative humidity is higher than 85 percent.
    5. Under dusty or adverse environmental conditions.

6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation.
   1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
   2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
      a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
   1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
   2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
   3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
   4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
   5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
      a. Entire curing period.
      b. 8 hours after coating.

E. Systems:
   1. Site electrical power availability as specified in Section 01_50_00 - Temporary Facilities and Controls.
   2. Internal combustion engine generators may be used.
      a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
      b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
      c. Locate engine generator outside hazardous classified areas per NFPA 820.
      d. Provide daily fuel service for generator for duration of use.
   3. Dehumidification:
      a. Provide desiccant or refrigeration drying.
      b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
      c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
   4. Heating:
      a. Use electric, indirect combustion, or steam coil.
      b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.

5. Filters:
    a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
    b. Do not allow air from the working area or dust filtration equipment to recirculate through thein dehumidifier during coating application or when solvent vapors are present.
6. Design and submittals:
    a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
    b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

1.09 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

1.10 CTR RESPONSIBILITIES

A. General:
1. Attend pre-installation conference.
2. Perform onsite application training.
3. Periodically inspect coating system application.

B. Coating system installation training:
1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
    a. Train a minimum of 2 supervisory personnel and 2 application personnel.
    b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
3. Minimum training requirements:
    a. Explain in detail the mixing, application, curing, and termination requirements.
    b. Provide hands-on demonstration of coating system mixing.
    c. Explain in detail the ambient condition requirements for temperature and humidity.
    d. Explain in detail the surface preparation requirements.
    e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
    f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
   1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
   2. Be on-site to oversee:
      a. Coating application at least once a week.
      b. End of surface preparation.
      c. During coating application.
      d. Post-cure inspection.
   3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
   4. Perform the following activities to confirm conformance with the specifications:
      a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
      b. Inspect each coated surface type and coating system applied to verify the following:
         1) Cleanliness.
         2) Surface pH for concrete substrates.
         3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
      c. Verify surface profile of substrates by completing the following:
         1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
         2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
         3) Verify proper mixing of coating materials.
         4) Inspect application of primers and finish coats, including wet and dry film thickness.
         5) Inspect coating systems for proper cure times and conditions.
      d. Review adhesion testing of cured coating systems.
      e. Review coating system continuity testing.
      f. Inspect and record representative-localized repairs.
      g. Conduct final review of completed coating system installation.
      h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM’s Recommendations.

D. Final report:
   1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits. Include a statement that completed work was performed in accordance with the requirements of the CSM’s recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

2.02 MATERIALS

A. General:
   1. Product requirements as specified in Section 01_60_00 - Product Requirements.

2.03 COATING SYSTEMS IDENTIFICATION

A. Naming Conventions: Coating Systems Identifications contain the elements defined in Table 1.

Table 1 Coating System Identification Elements

First Element	-	Second Element	-	Third Element	-	Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

1) First element identifies the coating type using the following abbreviations:
   a) ACR: Acrylic.
   b) CTE: Coal tar epoxy.
   c) ELA: Elastomeric acrylic.
   d) EPU: Epoxy-polyurethane.
   e) EPX: Epoxy.
   f) POL: Polyurethane.
   g) SIL: Silicone.
   h) SILX: Siloxane or silane.
   i) VE: Vinyl ester.
2) Second element identifies the substrate using the following abbreviations:
   a) C: Concrete or masonry.
   b) F: Concrete flooring.
   c) FRP: Fiber-reinforced plastic.
   d) GM: Galvanized metal.
   e) M: Metal.
   f) PVC: Polyvinyl chloride, chlorinated polyvinyl chloride.
3) Third element identifies the sequential system number.
   a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.

4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a) PWS: Potable water service applications (NSF-61 approved).
   b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c) BG: Below grade or buried.
   d) OZ: Organic zinc primer, epoxy polyurethane system.
   e) SC: Secondary containment.

2.04 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Attachment B - Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
      a. Emulsifying type.
      b. Containing no phosphates.
      c. Biodegradable.
      d. Does not damage zinc.
      e. Compatible with the specified primer.
      f. Complying with applicable air-quality control board requirements.
   2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
   2. Machined surfaces for sliding contact.
   3. Surfaces to be assembled against gaskets.
   4. Surfaces of shafting where sprockets will be fit.
   5. Surfaces of shafting where bearings will be fit.
   6. Machined bronze surfaces, including slide gates.
   7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
   8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
   1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
   2. After completing coating, reinstall removed items.
   3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Attachment B - Coating Detail Sheets include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

D. Where required by the Owner’s representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before applying a coating.
   1. CSA shall coordinate coating inspections:
      a. Identify coating inspection Hold Points during the pre-installation conference.
      b. Provide at least 2 days' notice before inspection.
   2. Contractor shall correct surface defects identified by the inspector at no additional cost to Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   4. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.

2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
2. Perform water jetting or water blasting in accordance with SSPC-SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultra-high-pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations and as indicated on the Drawings.
1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13.
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.

2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
3. Repair concrete defects and physical damage.
4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
5. Fill voids to provide surface as specified in Section 03_35_29 - Tooled Concrete Finishing.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
   a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
4. Comply with specified minimum moisture content and CSM’s written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
   5. Confirm that masonry surfaces are dry before coating application.
      a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter.
   1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.
   3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
   4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
   1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
   2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
   3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
   1. Smooth welds and prominences with power tools before applying field-applied coatings.
   2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
   3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
      a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
   4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
   5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
   1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
   2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
   1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
   2. Abrasive blast clean in accordance with SSPC-SP 16.
      a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
   4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16.
   2. Prepare in accordance with CSM's instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
   1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
    1. Lightly sand surfaces to be coated.
        a. Sand to remove gloss and establish uniform surface profile.
    2. Vacuum to remove loose dust, dirt, and other materials.
    3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer.
    1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
        a. Contractor shall provide CTR shop coating reports.
    2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
        a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
    3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC-SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified.
    1. Use compressors with moisture traps and filters that remove water and oils from the air.
        a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
    2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
    1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
    1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
    2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
    3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.

K. Spray application:
    1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
    2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
    3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
    4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove all dust on coatings between coats.

N. Shop and field coats:
    1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
        a. Provide data sheets identifying the shop primer to on-site coating application personnel.
        b. Perform adhesion tests on the shop primer.
        c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
        d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
    2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
        a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
    3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
        a. Prime coat adheres to the substrate.
        b. Coatings adhere to the prime and intermediate coats.
            1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
            2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
    1. Premix contents of component drums if required by the CSM each day.
    2. Before starting application:
        a. Verify gauges are working properly.
        b. Complete ratio checks.
        c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
        d. Label and retain all spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
    1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
    2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
    3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
        a. Do not allow excessive drying time or exposure, which may impair bond between coats.
        b. Recoat all coatings within time limits recommended by CSM.
        c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
    4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
    5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
    6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
    7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
    8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

R. Workmanship:
    1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
    2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
    3. Remove splatter and droppings after coating work is completed.
    4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
    5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
    6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
        a. Brush apply stripe coat to ensure proper coverage.

b. Do not stripe coat with spray or roller.

7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
   1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
   2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
   3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
   4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
   5. Mix coatings with 2 or more components in accordance with CSM's instructions.
   6. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating per CSM's recommendations.
      a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
      b. Thin coatings to only what is necessary to obtain proper application characteristics.
      c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
   1. Apply coating to the specified thicknesses.
      a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
   2. Verify WFT of the coating system first coat and after applying each subsequent coat.
   3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
   4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
      a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
   5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
   1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
   2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
   1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
   2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
   3. Areas damaged during erection:
      a. Prepare surface for spot repairs as specified for the coating system.
      b. Recoat with prime coat before applying subsequent coats.
      c. Touch up surfaces after installation.
      d. Clean and dry surfaces to be coated at time of application.
   4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
   5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
   1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application.
   1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
      a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
   2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM's instructions.
   3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
      a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
      b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
      c. Provide relatively flat, uniformly even surface before coating application.
   4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
      a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
      b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.

2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
    a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
    b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and drawings, whichever is stricter.

E. Concrete coating systems application requirements:
    1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. Attachment A - Schedule of Surfaces to be Field Coated specifies surfaces to be coated in the field with the coating systems required.

3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior Concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried Piping that is encased in concrete or cement mortar.

3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.
   9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
   10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   11. Perform adhesion testing.
   12. Measure and record the coating system's thickness.
   13. Verify proper curing of the coating system in accordance with the CSM's instructions.
   14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: chip back to expose entire cavity in all directions.
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool and strike off. Cure per CSM's recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.

7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM's instructions, if the maximum recoat time is exceeded.
9. Apply coating at specified dry film thickness.

3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.

C. Mark any rework required:
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPX-M-1	Metal Pipe Coating
EPX-M-1-PWS	Metal Pipe Lining
CTE-C-1	Concrete in contact with aluminum

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
- b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- c. Motors and motor accessory equipment.
- d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
- e. Valve and gate operators and stands.
- f. Structural steel.
- g. Crane and hoist rails.
- h. Exterior of tanks and other containment vessels.
- i. Mechanical equipment supports, drive units, and accessories.
- j. Bare electrical equipment: boxes, exposed conduit, and accessories.
- k. Pumps not submerged.
- l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Interior surfaces of ferrous metal tanks.
- b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- c. Bell rings, underside of manhole covers and frames.
- d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
- e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- f. Submerged pipe supports and hangers.
- g. Stem guides.
- h. Other submerged iron and steel metal unless specified otherwise.

ATTACHMENT B - COATING DETAIL SHEETS

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-1		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	None Applied	Carboguard 890
International Paint	Bar-Rust 236	None Applied	Bar-Rust 236
PPG	Amerlock 2/400 Series	None Applied	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646	None Applied	Macropoxy 646
Tnemec	Series 69	None Applied	Series 69
Service Condition	Interior, non-corrosive.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 12 mils		
Primer	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-1-PWS		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 891VOC	None Applied	Carboguard 891VOC
International Paint	Bar-Rust 233	None Applied	Bar-Rust 233
PPG	Amerlock 2/400 Series	None Applied	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646PW	None Applied	Macropoxy 646PW
Tnemec	Series V140	None Applied	Series V140
Service Condition	Interior, immersion, potable water.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Primed surfaces	1.0 to 1.5 mils on the intact primer.		
Nonferrous Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 12 mils		
Primer	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	CTE-C-1		
Coating Material	Coal Tar Epoxy		
Substrate	Concrete		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	No product specified	No product specified	No product specified
International Paint	None applied	Devtar 5A-HS	Devtar 5A-HS
PPG	None applied	Amercoat 78HB	Amercoat 78HB
Sherwin Williams	None applied	TarGuard	TarGuard
Tnemec	No product specified	No product specified	No product specified
Service Condition	Below grade in contact with soil.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Surface profile			
Concrete	ICRI CSP 3.		
Existing Coated Concrete	ICRI CSP 3.		
System Thickness (Dry Film)			
Total	16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
General	Fill all bugholes with a filler/surfacer compatible with the coating.		
Special CTR Training	Not Required.		

SECTION 09_96_08

CONCRETE REPAIR AND COATING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Coating of existing concrete, including coating systems, surface preparation, application requirements, and quality control requirements.

B. This section adds coating-specific requirements to the requirements in Section 09_96_01 - High-Performance Coatings. Requirements in Section 09_96_01 – High -Performance Coatings shall apply unless more stringent requirements are provided in this Section. Note specifically Coating System Manufacturer, Coating System Applicator, Coating System Manufacturer's Technical Representative, quality assurance, preparation, and execution requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-Inch Cube Specimens).
2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
3. C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
4. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
5. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
7. D638 - Standard Test Method for Tensile Properties for Plastic.
8. D1107 - Standard Test Method for Ethanol-Toluene Solubility of Wood.
9. D1653 - Standard Test Methods for Water Vapor Transmission of Organic Coating Films.
10. D2240 - Standard Test Method for Rubber Property - Durometer Hardness.
11. D2794 - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
12. D4060 - Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
13. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

B. NACE International (NACE):
1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

C. The Society for Protective Coatings (SSPC):
   1. SP-2 - Hand Tool Cleaning.
   2. SP-3 - Power Tool Cleaning.
   3. SP-10 - Near-White Blast Cleaning.

D. United States Department of Agriculture (USDA).

1.03 DESCRIPTION OF WORK

A. Furnish all labor, tools, equipment, materials, and other items required to:
   1. Apply 100 percent solids Elastomeric Polyurethane coating to all concrete surfaces as specified in this Section.

B. As determined necessary by the Engineer, remove all mechanical equipment and associated items where work is to be accomplished. Mark and prepare coating keyway for UV frames and mounting prior to coating. Do not coat at frame mounting locations. All other mechanical equipment mounting locations may be coated unless otherwise specified by the manufacturer or Engineer.
   1. Install such items upon completion of work.

1.04 AREAS OF WORK

A. Interior surfaces of UV Channels 1-2 as described in this Section:
   1. Prepare and coat all interior wall surfaces.

1.05 SEQUENCE OF WORK

A. Prepare interior surfaces of UV Channel 1, and UV Channel 2 in preparation for viewing by the Owner, Owner's Representative, Contractor, and coating manufacturer's technical representative:
   1. Wash and degrease all interior surfaces.
   2. Remove or protect any conflicting equipment items, such as slide gates and brackets, prior to abrasive blast cleaning of concrete surfaces.
   3. Abrasive blast clean all concrete surfaces to remove loose concrete and provide a "broom" type finish similar to 60-grit sandpaper.

B. Complete all necessary epoxy injection work, additional abrasive blast cleaning, and coating application as specified and required by the Owner or Owner's Representative and in this Section.
   1. Coating shall not extend to area under the UV frame mounting location.

C. Perform inspection and necessary repairs to coating as specified in this Section.

1.06 SUBMITTALS

A. Shop drawings: Submit prior to start of work.

B. Product data for 100 percent solids polyurethane coating:
   1. Manufacturer's literature including installation procedure and warranty for coating system.

2. Test results of product from approved material testing laboratory certifying that product meets or exceeds required physical properties.
3. Certification of manufacturer's technical services representative.

C. Testing procedure in accordance with ASTM D4263.

D. Coating applicator licensing:
1. Approval and licensing by manufacturer of 100 percent solids elastomeric polyurethane coating for coating applicator to apply this system.

E. Manufacturer's instructions: Submit in accordance with requirements for product data.

F. Manufacturer's technical representative's field reports.

G. Submittals required in Section 09_96_01 - High-Performance Coatings where not already included above.

1.07 QUALITY ASSURANCE

A. Qualifications of 100 percent solids elastomeric polyurethane coating applicator:
1. At least 5 years of experience applying type of coating under conditions similar to the Work specified in this Section:
a. Submit list of 5 references for similar projects completed.

B. Qualifications of 100 percent solids elastomeric polyurethane coating manufacturer's technical services representative:
1. Minimum 3 years of experience involving applications of 100 percent solids elastomeric polyurethane epoxy.
2. Shall be available as required to support application of specified product.

C. Regulatory requirements: Include requirements concerning the following:
1. Abrasives and abrasive blast cleaning techniques and disposal.

D. Pre-installation conference:
1. Conduct prior to start of work at mutually agreed time by the Owner, Owner's Representative, and Contractor.
2. Coating manufacturer's technical services representative shall attend pre-installation conference.

E. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

F. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Remove unspecified and unapproved materials from Project site immediately.

B. Deliver containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.

C. Store materials in a well-ventilated facility that provides protection from the sun, weather, and fire hazards.
   1. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.

D. Take precautions to prevent fire and spontaneous combustion.

E. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

1.09 PROJECT CONDITIONS

A. Surface moisture contents: Do not coat surfaces that exceed coating manufacturer specified moisture contents.

B. Do not coat:
   1. Under dusty conditions.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 45 degrees Fahrenheit.
   4. When relative humidity is higher than 85 percent.
   5. When surface temperature is less than 5 degrees Fahrenheit above dewpoint.
   6. When surface temperature exceeds coating manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless coating manufacturer allows a higher temperature.

C. Provide fans, heating devices, dehumidification equipment, or other means recommended by manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats, and within curing time following application of last coat.

D. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

1.10 WARRANTY

A. As specified in Section 01_77_00 - Closeout Procedures and Section 01_78_36 - Warranties and Bonds.

B. Special warranty:
   1. Duration: 1 year warranty on concrete repair and coating work accomplished under this Contract stating that Contractor will provide all labor and materials to repair any defects that occur after completion and acceptance date of work at no cost to the Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. 100 percent solids polyurethane coating materials:
   1. The following or equal:
      a. Global Eco-Technologies, Inc. EnduraFlex EF-1988.

2.02 MATERIALS

A. Elastomeric polyurethane coating:
   1. 2 components, 100 percent solids, elastomeric polyurethane which contains no sand or silica fillers.
   2. Certified by an approved material testing laboratory to be resistant to hydrogen sulfide and sodium hypochlorite and meet the following requirements:

Physical Properties	Test Method	Results
Durometer Hardness @ 75 Degrees Fahrenheit, Shore D	ASTM D2240	50-70 Shore D
Tensile Strength	ASTM D638	2,800-3,000 pounds per square inch
Percent Elongation	ASTM D638	65 percent
Abrasion Resistance	ASTM D4060	53 milligrams
Impact Resistance	ASTM D2794	35 pounds per square inch
Tear Resistance	ASTM D624	Greater than 200 pounds per square inch
Water Vapor Permeability	ASTM D1653 Test Method A, at 75-80 mils	0.048 grams per 23 hours per foot squared

   3. Systems, one of the following or equal:
      a. Endura-Flex EF-1988:
         1) Apply total dry film thickness (DFT) of 120-130 mils, or as required to be pin-hole free, consisting of a minimum 70 mils of expanded Endura-Flex EF 1988 with minimum 50 mils topcoat of solid Endura-Flex 1988.
   4. Primer, one of the following or equal:
      a. Endura-Flex 1200P Epoxy Primer:
         1) Only to be used in conjunction with Endura-Flex EF-1988.
         2) Primer to be used only as recommended by coating manufacturer's technical representative. Standard DFT is 2-4 mils.

PART 3 EXECUTION

3.01 GENERAL PREPARATION

A. Prepare areas to receive UV module frames before applying the coating. Protect these areas and other equipment or surfaces not scheduled to receive coatings.

B. Wash and degrease all surfaces prior to abrasive blasting.

C. Utilize abrasive blast cleaning to remove surface contaminants and loose material for preparation of concrete surfaces.
   1. Remove debris from structure and dispose of material off site:
      a. Compressed air used for blasting or blow downs must be clean and free of oil particles.
      b. Air compressors must be equipped with efficient oil and water traps.

D. Provide necessary heaters, fans, or dehumidification equipment to allow concrete to cure and to be surface dry for coating application.

E. Cleanliness:
   1. At the direction of the coating manufacturer's technical representative or the Owner or Owner's Representative, all surfaces shall be pressure cleaned with clean, potable water at a minimum pressure of 1,500 pounds per square inch to remove all dust, dirt, and other debris prior to the application of the elastomeric polyurethane coating.

F. Expansion joints:
   1. Seal expansion joints with bond breaker tape.
      a. Polyethylene-backed adhesive tape is acceptable.
   2. Prior to installation of bond breaker tape, round-off sharp edges, remove debris/dust, and inspect to assure that joint compound is reasonably flush with top edge of expansion joint.
   3. Apply a tack coat of elastomeric polyurethane coating material to adjacent areas, followed immediately with installation of the tape.
   4. Install tape centered over the joint and be of sufficient width to extend a minimum of 1 inch onto the concrete on both sides of the joint.
   5. Tape thickness should be no more than 50 percent of the specified coating thickness.
   6. Topcoat bond breaker tape with elastomeric polyurethane coating material to the minimum specified thickness.

G. Inspection:
   1. After completion of surface preparation, the Owner, Owner's Representative, and coating manufacturer's technical representative, will inspect all surfaces to be coated prior to coating.
   2. Specified cleanliness shall be verified through the use of accepted practice in accordance with SSPC or NACE standards.
   3. Utilize visual comparators to verify the specified level of cleanliness.

H. Abrasive-blast and concrete debris:
   1. Remove debris generated from the preparation operations from the structures.
   2. Haul and dispose of debris in accordance with all federal, State, and local regulations.

I. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

3.02 COATING APPLICATION

A. Equipment requirements:
   1. Utilize plural component proportioning equipment capable of pumping 2 separate streams of polyurethane components at the required ratio volumetrically.
   2. Have capability to heat the 2 different liquid components to a process temperature range from 100 to 125 degrees Fahrenheit depending on the set-up.
      a. Do not use of band heaters.
   3. Have capability to maintain process temperature to spray through a gun or pour through the nozzle.
      a. The use of insulated heat-trace fluid lines is mandatory.
   4. Have capability to pump at pressures ranging from 1,200 pounds per square inch to 3,000 pounds per square inch.
   5. Have capability to bring the 2 separately proportioned streams together as one stream and mix them together to provide a homogenous mixture for reacting into a solid polymer of known properties.
   6. Provide spray atomization tip sizes matched to the pumping equipment output which provides a fully atomized spray pattern, free of “fingers” without the addition of solvents of any kind.

B. Before start of application and at such times when long breaks are involved or application of equipment malfunctions, the following 4 material quality tests are recommended:
   1. A ratio check to verify required volumetric proportioning.
   2. A mixed material check to verify proper mixing of components.
   3. Curing cycle test to verify the proper reaction is under way.
      a. At least a pint sample is to be utilized.
      b. First Durometer results should be determined within 15 minutes.
   4. A weight check (10 ounces. Container with solid material and a 10 ounce. Container with expanded material) to verify proper expansion rate.

C. All surfaces receiving the coating shall be visually dry and at least 5 degrees Fahrenheit (3 degrees Centigrade) above the dew point prior to starting the installation to prevent moisture entrapment:
   1. The relative humidity must be below 85 percent.
   2. Test surfaces to be coated in accordance with ASTM D4263.
      a. Test method for indicating moisture in concrete is by the plastic sheet method.

D. Compressed air used for coating application shall be clean and free of oil and water.

E. Use primer only at direction of, and as recommended by coating manufacturer's technical representative.

F. Mix polyurethane base component thoroughly with a power mixer.
   1. Heat base and activator to 100 to 110 degrees Fahrenheit prior to use.

G. Materials conditioning:
   1. Perform in accordance with manufacturer's latest published data.
   2. Control temperature in order to produce a repeatable finished product on each application.

H. Deposition of materials: Apply coating to be monolithic and cohesive in nature and to minimize hand work repair.

I. Leading edges: Install a mechanical anchor for the leading edge of the applied coating material:
   1. Leading edge mechanical anchor shall consist of a saw cut to a minimum depth of 1/4 inch and width of 1/8 inch.
   2. Sharp edges of the saw cut shall be rounded, dried, and cleaned of debris.
   3. After cleaning, solid base elastomeric polyurethane coating shall be applied into the saw cut, taking care to penetrate to full depth. The use of a trowel or putty knife might be required.
   4. After installation of the leading edge, topcoat the area with composite elastomeric polyurethane coating material.
      a. Tape-off adjacent areas not scheduled for coating and protected from overspray.

J. Curing:
   1. Protect finished coating from damage during curing.
   2. Cure coatings as recommended by coating manufacturer for a minimum of 3 days before coated areas are placed in service.

K. Cleanup: Clean spillage and overspray from adjacent surfaces as recommended by coating system manufacturer.

3.03 INSPECTION AND TESTING

A. The following inspection equipment (or Engineer accepted equal) shall be provided and utilized for performing quality control testing:
   1. Sling psychrometer.
   2. Surface temperature thermometer.
   3. Ambient temperature thermometer.
   4. Psychrometric charts for determining relative humidity and dew point.
   5. High range wet and dry film thickness gauges.
   6. Micrometer.
   7. Durometer: A scale.
   8. Sample cans.
   9. Inspection glass: 30 power minimum.
   10. High voltage holiday detector.

B. The following quality control tests shall be performed, with results recorded and made available to the Engineer:
   1. Compressed air quality in accordance with blotter test.
   2. Environmental conditions prior to coating application, including substrate temperature, ambient temperature, relative humidity, and dew point.
   3. Observation of surface preparation, including anchor pattern prior to coating application.
   4. Results of ratio check of plural component proportioning equipment.
   5. Wet and dry film thickness measurements.

C. The Owner, Owner's Representative, and coating manufacturer's technical representative shall be given sufficient notice so as to be present when the following hold points are reached:
   1. Completion of surface preparation.
   2. Prior to coating application.
   3. During wet and dry film thickness measurements.
   4. During holiday detection testing.

D. Surface cleanliness, pH condition:
   1. Use either pH paper or a pH meter to determine the pH of the concrete surface.
   2. A pH range of 5 to 9 is considered acceptable.

E. Enlist the aid of various tests and implement those tests to verify the integrity of the applied coating.
   1. Permit the Owner, Owner's Representative, and coating manufacturer's technical representative full access at all times to observe and be satisfied that the specification is being followed.

F. Wet film thickness shall be monitored throughout the coating installation by means of frequent measurements with a high-range wet film thickness gauge.

G. All layers of material (expanded and solid) shall be applied the same day. This procedure is to ensure minimization of contamination of the coating:
   1. If project is not completed, then at the end of the workday, a 3- to 12-inch "returning edge" of material will be left tapered to the substrate for the start of the next working day.
   2. The "returning edge" shall be cleaned with MEK before proceeding to spray on start up to the following workday.

H. Coating shall be 100 percent electronically tested using high voltage in accordance with NACE procedure SP0188 inspected for discontinuities to include pinholes, voids, and mechanically damaged areas.
   1. Any damaged areas, faulty areas, or discontinuities (pinholes) found during holiday detection within a 24-hour (within recoat window) period of application shall be corrected as follows:
      a. Damaged or faulty areas (i.e., impact damage, off-ratio application):
         1) Clean area thoroughly, extending at least 6 inches beyond damaged area with MEK dampened cloth.
         2) Do not apply excessive MEK to repair area, the intent is to clean only.

3) Allow MEK to thoroughly dry.
4) When thoroughly dry to touch, spray area with coating to the specified thickness, feathering material into existing coating.
5) In the event that the damaged area exhibits a discolored substrate substandard to the specified requirements, these areas shall receive the same degree of surface preparation required by the original project specifications prior to application of the coating material.

b. Discontinuity (pinhole) repair:
1) Clean the immediate area around the detected discontinuity with MEK dampened cloth (do not apply excessive MEK to pinhole area, the intent is to clean only), allow MEK to thoroughly dry.
2) Hand apply (putty knife, etc.) a small amount of mixed material directly to the pinhole.
3) For pinhole repairs, hand mix and thoroughly blend a small amount (normally 2 or 3 ounces at a time, for each applicator) of Part A and Part B in correct ratios.

2. Any damaged areas, faulty areas, or discontinuities (pinholes) found during holiday detection inspection after 24 hours of coating installation (exceeding recoat window) shall be corrected as follows:
a. Damaged or faulty areas (i.e., impact damage, off-ratio application, etc.):
1) Abrade the surface using a power grinder and/or power steel grinding brush down to and including exposed bare concrete to roughen the surface and to prepare the substrate to the original standard.
2) Abraded areas shall extend at least 6 inches (15 centimeter.) beyond damaged or faulty area.
3) After abrading the surface, vacuum or blow down with clean, dry compressed air thoroughly to remove all loose particles.
4) Clean the area thoroughly, extending at least 6 inches (15 centimeter) beyond the damaged area with MEK dampened cloth (do not apply excessive MEK to pinhole area, the intent is to clean only), allow MEK to thoroughly dry.
5) When thoroughly dry to touch, spray area with coating to the specified thickness, feathering the material into the existing prepared coating.

b. Discontinuity (pinhole) repair:
1) Abrade (hand sand or power tool clean) the immediate areas around the detected pinhole (1/2-inch radius from edge of discontinuity) to establish a roughed surface, and to prepare the substrate to the original standard, followed with vacuuming or blow down with clean, dry compressed air to remove loose particles.
2) After dust removal, wipe abraded area with MEK dampened cloth.
3) Do not apply excessive MEK to pinhole area.
4) The intent is to clean only. Allow MEK to thoroughly dry.
5) Hand apply (putty knife, etc.) a small amount of mixed material directly to the pinhole.
6) For pinhole repairs, hand mix and thoroughly blend a small amount (normally 3 ounces at a time for each applicator) or Part A and Part B in correct ratios.

I. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

3.04 FINAL INSPECTION AND ACCEPTANCE

A. Final inspection:
   1. Following replacement of previously removed items, a final inspection of the repaired and coated structures shall be made by the Owner, Owner's Representative, Contractor, and the coating manufacturer's technical representative.
   2. Any damage that has occurred to the coating shall be repaired in accordance with the coating manufacturer's instructions.

B. Final acceptance:
   1. Written final acceptance of the concrete repair and coating work accomplished to the interiors of the UV Channel structures, as specified in the Contract Documents, shall be prepared by the Owner or Owner's Representative and issued to the Contractor, with a copy to the coating manufacturer.

C. As required in Section 09_96_01 - High-Performance Coatings where not already included above.

END OF SECTION

SECTION 10_14_00

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic and metal signs for building and site use.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.

C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
   1. Seton Name Plate Co., Special Wording.
   2. Emedco.

B. Danger sign colors:
   1. Background: White.
   2. Heading: White lettering on red oval with white border in black rectangular panel.
   3. Message: Black lettering on white.
   4. Size: As scheduled.

C. Caution sign colors:
   1. Background: Yellow.
   2. Heading: Yellow lettering on black rectangular panel.
   3. Message: Black lettering on yellow.
   4. Size: As scheduled.

D. Safety instruction signs:
   1. Background: White.
   2. Heading: White lettering on green rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

E. Warning sign colors:
   1. Background: Orange.
   2. Heading: Black lettering on orange diamond in black rectangular panel.
   3. Message: Flack lettering on orange.
   4. Size: As scheduled.

F. Notice information signs:
   1. Background: White.
   2. Heading: White lettering on blue rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.

H. See Attachment A - Metal Safety Sign Schedule for specific sign size, location, text, and quantity.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs where indicated on the Drawings or as indicated in the following Attachments.

END OF SECTION

ATTACHMENT A - METAL SAFETY SIGN SCHEDULE

METAL SAFETY SIGN SCHEDULE

A. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically by remote control.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
      BY REMOTE CONTROL

B. HIGH VOLTAGE WARNING:
   1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: HIGH VOLTAGE
      KEEP OUT

C. UV WARNING:
   1. Location: On door to area with UV equipment, and adjacent to UV equipment on wall or column.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: CAUTION
   5. Wording: HIGH INTENSITY ULTRAVIOLET LIGHT
      WEAR EYE PROTECTION

SECTION 26_00_10

ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Electrical requirements.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, City's Programmer and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_14_00 - Work Restrictions.
      b. Section 01_33_00 - Submittal Procedures.
      c. Section 01_45_00 - Quality Control.
      d. Section 01_45_24 - Regulatory Quality Assurance.
      e. Section 01_50_00 - Temporary Facilities and Controls.
      f. Section 01_75_17 - Commissioning.
      g. Section 01_77_00 - Closeout Procedures.
      h. Section 01_78_24 - Operation and Maintenance Manuals.
      i. Section 01_81_50 - Design Criteria.
      j. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      k. Section 05_12_00 - Structural Steel Framing.
      l. Section 40_61_11 - Control System Requirements.
      m. Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse.

C. Overview of Electrical Work:
   1. See Specification Section 01_14_00 - Work Restrictions for additional electrical requirements. Section 01_14_00 - Work Restrictions includes a proposed, sequential work procedure, equipment shutdown constraints and a description of temporary system power requirements. The requirements of Section 01_14_00 - Work Restrictions are intended to complement electrical requirements specified in this Section and indicated on the Drawings.
   2. See Specification Section 40_61_11 - Control System Requirements for additional requirements related to the electrical system.

3. The Work shall include electrical system improvements in several areas within the existing facility including, but not limited to, the following:
    a. Electrical and control system provisions for installation of the following equipment:
        1) Temporary ultraviolet (UV) disinfection system and associated temporary pumping equipment.
        2) Permanent UV system equipment.
    b. Provide temporary power, control and signal provisions and connections to maintain both existing UV system and temporary UV system continuous operation throughout the construction period. See Specification Section 01_14_00 - Work Restrictions for additional construction sequencing requirements and work constraints.
    c. Disconnect and remove existing active harmonic filter equipment located within the Plant main structure electrical room.
    d. Provide new, temporary 480-volt panelboards PNL-TEMP1 and PNL-TEMP2, connected to existing main supply feeder conductors as indicated on the Drawings for temporary power supply to temporary UV system equipment.
    e. Disconnect and remove existing supply feeder conductors routed from existing switchboard SB-UV located in the Plant main structure electrical room to the UV process area.
    f. Disconnect and remove existing panelboard PNL-3EB transformer supply feeder conductors routed from existing motor control center MCC-3EM in the Plant main structure electrical room to the UV process area.
    g. Disconnect and remove existing electrical and control system equipment associated with the existing UV system equipment as indicated on the Drawings.
    h. Provide new 480-volt panelboards 40-PNL-11 and 40-PNL-21 at locations indicated on the Drawings.
    i. Remove existing feeder circuit breakers and replace with new feeder circuit breakers within existing switchboard SB-UV located at the Plant main structure electrical room as indicated on the Drawings.
    j. Provide new below-grade electrical conduit ductbank from the Plant main structure to the UV process area as indicated on the Drawings.
    k. Provide new 480-volt main supply feeder conductors from the Plant main structure electrical room to new 480-volt panelboards 40-PNL-11 and 40-PNL-21.
    l. Provide new 480-volt main supply feeder conductors from new 480-volt panelboard 40-PNL-11 to existing UV process area lighting panelboard PNL-3EB transformer equipment.
    m. Provide new electrical and control system equipment and materials for connection of new UV system equipment.
    n. Provide all other miscellaneous electrical and control system equipment and materials as shown and specified in the Contract Documents and as required for a complete and operable system installation.
4. Work shall be performed sequentially as specified in Section 01_14_00 - Work Restrictions and shall be closely coordinated and sequenced with overall project piping, structural and mechanical installation work.
5. Provide new raceway systems, cables and conductors as required by the Contract Documents.

6. Provide third-party, independent testing of new equipment and installations as specified in this Section.
7. Power distribution system short circuit, coordination and arc flash hazard studies shall be performed by the Contractor. Upon acceptance of the studies by the Engineer, Contractor's testing firm shall implement the recommended protective device settings prior to field testing of protective devices.
8. Programming modifications to existing plant PLC programming and programming modifications to the plant SCADA system shall be performed by the Contractor's Programmer. The Contractor's project completion schedule shall include separate entries for PLC and SCADA system programming activities, control system start-up, testing and commissioning as specified in the Contract Documents. Control strategies related to the new system programming are included in the approved Trojan UV submittals and the Programming RFP. Contractor shall retain the services of the pre-selected Programmer specified in Section 40_61_11 - Control System Requirements and the Contract Documents.

1.02 GENERAL ELECTRICAL REQUIREMENTS

A. Provide a tested and working electrical system as indicated in the Contract Documents. System includes all items not specifically mentioned in these Specifications or indicated on the Drawings or accepted Shop Drawings, but which are obviously necessary to make a complete and working installation, and shall be deemed to be included herein.

B. Immediately notify City, in writing, of discrepancies within the Contract Documents and discrepancies between the Contract Documents and actual field conditions.

C. The Contract Documents indicate or specify minimum sizes of equipment, electric devices, and other components of the electrical system, but the Contract Documents do not indicate every offset and fitting, or every structural or mechanical difficulty that may be encountered during the execution of the Work.

D. Install equipment at locations indicated on the Drawings as closely as field conditions permit. Obtain accepted equipment submittal dimensions prior to installing pads and conduit.

E. Make minor variations to alignment of equipment and/or installation of raceway systems to avoid conflict with other portions of the Work or existing infrastructure.

F. Demolition of existing equipment as indicated on the Drawings shall include all associated conduit and conductors connected to demolished equipment in entirety.

G. Prior to demolition or modification of the following existing equipment, the Contractor shall notify the City that the equipment is ready for disposal in order to provide the City with an opportunity to salvage any components related to the equipment. Contractor shall provide a minimum of one week of notice to the City:
   1. Existing feeder circuit breakers removed from switchboard SB-UV.

H. Contractor shall schedule pre-installation field meetings with the City prior to installing new raceways and electrical equipment within the existing UV process area. During these field meetings, Contractor shall provide an overview of the intended conduit and cable tray routing paths and new equipment placement locations to ensure that proper clearances and equipment access will be maintained after installation of the new equipment. Immediately following each area field meeting, the Contractor shall prepare written meeting summary notes summarizing each discussion. The field meeting notes shall be submitted to the City for review and acceptance prior to installing new equipment and materials within the existing UV process area.

I. Contractor shall develop and submit complete interconnection wiring diagrams as specified herein for all systems provided which require connections of all new power, control signal and communication conductors. Interconnection wiring diagrams shall submitted for review by the City. No field wiring terminations shall be performed until after acceptance of the Contractor's interconnection wiring diagrams by the City.

J. Temporary Utilities:
   1. Provide and maintain temporary utilities in accordance with Section 01_50_00 - Temporary Facilities and Controls.
   2. Install temporary wiring in as indicated on the Drawings and in accordance with NEC Article 590 with Type SOOW (SO cord) portable cable and diesel locomotive cable (DLO cable), watertight connections, and ground fault interrupting equipment. After construction is completed, remove all temporary systems.
   3. Temporary DLO cable shall be RoHS Compliant, MSHA accepted, UL listed as Type RHH-RHW-2 per UL 44, CSA listed as type RW90 1kV per C22.2 No. 38-95 and meet FT-4 and VW-1 Flame Tests. Manufacturer shall be Southwire or accepted equal.
   4. Temporary SO cord shall be rated 600 volts, 90 degrees Celsius, black jacket, NEC rated Extra-Hard Usage, RoHS Compliant, UL listed. Manufacturer shall be Southwire or accepted equal.
   5. During the course of the Work at each location, it will be necessary to de-energize existing panelboards which supply power to area lighting and receptacles. During such panelboard outages, the Contractor shall be responsible for providing temporary power for tools and equipment and also providing temporary lighting necessary for performing the Work. Pending City written approval, the Contractor may be permitted to obtain temporary power from alternate locations within the treatment plant.
   6. The City shall be responsible for providing temporary power provisions to existing programmable logic controller (PLC) and network communication equipment should power supply to this equipment be required to be energized for relatively short durations during the course of the Work.
   7. Temporary utilities and installations shall be provided in a manner which does not impede normal facility access, operation and maintenance.
   8. Additional temporary electrical conductors and installations not indicated on the Contract Documents but required during the course of the Work shall be provided in accordance with Section 01_50_00 - Temporary Facilities and Controls.

K. Upon delivery of new indoor-rated electrical power distribution and control equipment to the Project site, temporary storage of equipment until placed in final installation location shall be indoors in a heated, climate-controlled building or structure. Temporary outdoor storage of indoor-rated electrical equipment is prohibited. Equipment stored outdoors in this manner is not acceptable and shall be replaced by the Contractor at no additional cost to the City. No overall construction schedule time extension shall be granted for replacement of improperly stored electrical equipment.

L. Upon delivery of new outdoor-rated electrical power distribution and control equipment to the Project site, the Contractor shall provide temporary power supply to internal equipment space heating equipment until the equipment is installed in its permanent location and is energized from the permanent power source required by the Contract Documents.

1.03 PERFORMANCE REQUIREMENTS

A. Operate electrical equipment successfully in all control modes at full-rated load, without failure, as required by the Contract Documents.

1.04 SUBMITTALS

A. See Specification Section 01_33_00 - Submittal Procedures for additional requirements.

B. Product Data: Include catalog data for all new electrical materials and new equipment including, but not limited to, power distribution equipment (both new and temporary equipment), local control panels and associated components, conduits, conductors, cable trays, wireways, pullboxes and hardware specified herein and indicated on the Drawings. Catalog data shall be “arrowed” to indicate exact proposed sizes, catalog numbers, etc. for each item.

C. Interconnection Diagrams: Customized electrical interconnection diagrams shall be developed by the Contractor and submitted for review by the Engineer which include all provided, new power, control, signal and communication conductors and cables. Diagrams shall include all new field wiring and cables provided to interconnect all new and existing power distribution equipment, PLCs, UV system equipment, 480-volt panelboard equipment and all connections to new field devices and instrumentation. The Contractor’s interconnection diagrams shall be coordinated with electrical diagram information furnished with the new UV system equipment and shall include specific termination identification information indicated on the UV system supplier’s electrical documentation. The Contractor’s interconnection diagrams shall supplement and be in addition to the electrical connection information indicated on the UV system documentation and shall include all new field power, control, signal and communication conductors and cables required for interconnection of the new UV system equipment, all new connections to field devices, equipment and instrumentation and all connections to existing facility electrical and control system equipment. The Contractor’s interconnection diagrams shall include specific, unique terminal block numbers for all new field conductor and cable termination locations. For interconnections between different pieces of equipment, continuation references shall be included on each individual

interconnection diagram which identifies the equipment and specific submitted drawing number for continuation of each interconnection conductor and cable. Raceway system information shall not be indicated on interconnection diagrams. Additional requirements for interconnection diagrams are as follows:

1. Prior to the Contractor's development of interconnection diagrams, the Contractor shall organize either a virtual or onsite meeting with the City and the Engineer to clarify interconnection diagram requirements and review sample, representative diagrams proposed by the Contractor. At this meeting, the Contractor shall present representative interconnection diagram samples to the City and Engineer and clarify any questions regarding the development of interconnection diagrams during this meeting.
2. Prior to commencing with any new field conductor and cable terminations, connection or splice work, interconnection diagrams shall be accepted by the City with a submittal designation of "Accepted - No Exceptions Taken". At all times during the course of the Work, the interconnection diagrams being utilized by the Contractor shall identically match the accepted version of the interconnection diagrams submitted to the City.
3. The Contractor shall propose unique conductor tag numbers for each field conductor termination location. The developed tagging scheme shall utilize a "From/To" approach with the circuit power source listed first. Examples of acceptable tagging schemes are listed below for various locations pertinent to the Project Work:
    a. Power Conductors (from 480-volt panelboard to UV system power distribution center):
        1) 40-PNL-11 / 40-PDC-11 ØA-1.
    b. Communication Cables:
        1) 40-MCP-01.
    c. Control Conductors (from UV system master control panel to UV system field device):
        1) 40-MCP-01: -<*terminal block number at MCP*> / 40LIT002.
4. The City shall review the Contractor's initial, proposed interconnection diagram tagging scheme and provide markups as required that modify the initially proposed tagging scheme and return the markups to the Contractor for incorporation and resubmittal of the interconnection wiring diagrams.
5. Submitted interconnection wiring diagrams with incomplete or missing conductor or cable tag number information shall be rejected without review.
6. During the course of the Work, the Contractor shall note with neat and legible hand markups that reflect any modifications to the accepted interconnection diagrams that may occur during installation. Upon completion of installation in a work area, a single, neatly hand-marked set of accepted interconnection diagrams shall be submitted to the City for review. After acceptance of this hand-marked set of "As Built" interconnection diagrams by the City, the Contractor shall electronically incorporate the hand markups and submit a final set of "As Built" interconnection diagrams to the City for review.
7. It is acceptable to submit a single, complete set of interconnection diagrams for the entire Project or "sets" of interconnection diagrams that are pertinent to each unrelated, separate work area or separate phase of work. If the Contractor elects to submit separate interconnection diagrams for each work area or work phase then upon completion of construction, the Contractor shall submit a final, single, compiled set of "As Built" interconnection diagrams to the City for review.

D. Conductor Pulling Calculations: Contractor shall perform pulling calculations for new main feeder conductors routed from existing switchboard SB-UV to each new 480-volt panelboard located in the UV area utilizing specialized pulling calculation software. Pulling calculations shall be based on actual, installed new raceway system information and existing raceway system information, calculated for both directions of pulling. Calculations shall include a summary of cable tension and sidewall pressure values with a summary section that indicates that the planned cable installation method does not exceed the cable manufacturer's recommended tension and sidewall pressure limitations for the accepted conductors. Acceptable pulling calculation software shall be Poly Water Pull Planner 3000 or accepted equal.

E. Structural Calculations: Perform structural calculations in accordance with Section 01_81_50 - Design Criteria. Anchoring requirements for new electrical equipment and installations shall be verified with structural calculations performed, stamped and signed by a licensed California Structural or Civil Professional Engineer. Calculations shall include the following areas of work:
   1. Anchoring provisions for new, UV system Master Control Panel 40-MCP-01.
   2. Anchoring provisions for new, UV system Power Distribution Center 40-PDC-11.
   3. Anchoring provisions for new, UV system Power Distribution Center 40-PDC-12.
   4. Anchoring provisions for new, UV system Hydraulic System Center 40-HSC-11.
   5. Anchoring provisions for new, UV system Power Distribution Center 40-PDC-21.
   6. Anchoring provisions for new, UV system Power Distribution Center 40-PDC-22.
   7. Anchoring provisions for new, UV system Hydraulic System Center 40-HSC-21.

F. Structural calculations shall summarize the adequacy of proposed supports and anchoring where indicated on the Drawings for each work location and provide any recommendations for additional support provisions based on the results of the structural calculations. New equipment requiring structural calculations shall not be installed until the structural calculations have been accepted by the City.

G. Cutting and Patching Requests: Notify City of cutting and patching work planned for existing equipment, roadways, sidewalks, and structures prior to performing such work.

H. Submit field X-ray or scan photos for all locations where penetration of existing concrete walls, floors and ceilings are planned. Locations required to be x-ray or scan photographed include core drills, window cut-outs and drilling for conduit supports. X-ray or scan photos shall clearly show existing wall reinforcing steel and embedded conduits with overlay of planned core drill, saw cutting and anchor drilling locations that confirm no existing reinforcing steel or embedded electrical will be hit during drilling or cutting.

I. Project Record Documents: The Contractor shall maintain a neat and orderly set of as-built record drawings, specifications and UV system shop drawings which reflect any deviations from the Contract Documents, shop drawings and submittal data in accordance with the requirements specified in Section 01_77_00 - Closeout Procedures. Documents shall be updated a minimum of once per week to reflect any field installation changes.

J. Acceptance Testing Information and Documents: Testing shall be performed in accordance with the requirements specified in Section 01_45_24 - Regulatory Quality Assurance, 01_75_17 - Commissioning, and as specified herein:
   1. Contractor shall retain the services of an independent, third-party independent testing firm to perform all field electrical testing specified herein. Provide the services of one of the following testing firms or accepted equal:
      a. Pacific Power Testing.
      b. Power Systems Testing.
   2. Proposed Third-Party, independent testing firm qualifications including “NETA Accredited Company” certification and resumes for all proposed field technicians.
   3. Pre-testing submittal:
      a. Provide a comprehensive list of all equipment and components included in the field testing scope of work.
      b. Provide a complete set of “blank” equipment and system testing forms for all equipment and materials to be tested as specified in Part 3.00.
      c. Loop calibration and testing forms in accordance with ISA standards for all new instrumentation provided with the UV system equipment (for instruments with both analog and discrete signal connections).
   4. Equipment Pre-Energization Testing: Equipment and materials shall be tested in accordance with InterNational Electrical Testing Association (NETA) ANSI/NETA ATS-2021 “Standard for Acceptance Testing Specifications” as specified herein prior to energization of equipment or materials.
   5. Pre-Energization Post-Testing Submittals (for testing performed prior to equipment energization): Complete set of individual equipment and system field testing data sheets indicating test values, summary evaluation of equipment and repair recommendations. Forms shall be electronically completed upon completion of testing and submitted to the City for review and acceptance prior to equipment energization or performing system functional testing. Testing forms shall clearly indicate any deficiencies or repair recommendations noted during testing along with resolution recommendations. For equipment and installations found to have deficiencies during field testing, Contractor shall make the necessary repairs and the equipment/installation shall be re-tested until acceptable results are obtained. Repeated testing shall be performed as required at no additional cost to the City.
   6. Loop testing results for each new discrete and analog signal loop associated with the new UV system equipment.
   7. Functional Test Plan – Field Testing: As specified in Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse
   8. Post-testing submittals (for testing performed after system start-up): Comprehensive thermographic survey report with thermographic color photographs of each location specified herein. Photographs of all scanned locations shall be included with any “hot spots” clearly identified. Contractor

shall make any necessary component replacement or repair work to resolve “hot spots” and perform a follow-up thermographic survey of the location to verify that the “hot spot” no longer exists. Follow-up scanning and associated submittals shall be submitted to the City for review and acceptance. All required follow-up scanning and submittals shall be provided by the Contractor at no additional cost to the City.

K. Operation and Maintenance Data: Submit in accordance with Section 01_78_24 – Operation and Maintenance Manuals and as specified herein.

1.05 QUALITY ASSURANCE

A. Regulations and Codes: Perform electrical work, including connection to electrical equipment integral with mechanical equipment, in accordance with latest published requirements of the following codes and code/standard making organizations:
   1. American National Standards Institute (ANSI).
   2. American Society for Testing and Materials (ASTM).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. Insulated Cable Engineers Association (ICEA).
   5. International Society of Automation (ISA).
   6. National Electrical Code (NEC).
   7. National Electrical Contractors Association (NECA).
   8. National Electrical Safety Code (NESC).
   9. National Electrical Manufacturers Association (NEMA).
   10. InterNational Electrical Testing Association (NETA).
   11. National Fire Protection Association (NFPA).
   12. State and local codes.

B. Materials and equipment used in performance of electrical work shall be listed or labeled by Underwriter's Laboratories (UL) for the class of service intended.

C. Quality control shall be in accordance with the requirements specified in Section 01_45_00 - Quality Control.

PART 2 PRODUCTS

2.01 SUPPORT CHANNELS AND ASSOCIATED HARDWARE

A. Provide supports and hardware in accordance with the requirements specified in Section 05_12_00 - Structural Steel Framing and provide anchoring in accordance with Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry unless otherwise indicated on the Drawings or specified herein.

B. All locations: 316 stainless steel.

C. Manufacturers: The following or accepted equal:
   1. Cooper Industries.
   2. Unistrut.

2.02 ANCHOR BOLTS AND HARDWARE

A. 316 stainless steel for all locations.

B. Provide adhesive anchors for all floor, wall, ceiling, and slab-mounted equipment and supports.

C. Anchor embedment minimum depth shall be as indicated on the Drawings. Where not indicated on the Drawings, embedment depth shall be as recommended by the adhesive anchor manufacturer's recommendations based on the accepted anchor material submittal information and in accordance with the Contractor's accepted structural calculations.

D. Sizes: As indicated on the Drawings, modified as required by the Contractor's accepted structural calculations.

2.03 NAMEPLATES

A. Black lamacoid with 1/2-inch high white letters fabricated from minimum 1/8-inch thick, two-ply phenolic limacoid.

B. Fastened with 316 stainless steel screws to all locations, new electrical equipment and enclosures.

C. Submittals: Include comprehensive nameplate engraving legend for all nameplates provided.

2.04 CONDUIT AND CONDUCTOR IDENTIFICATION

A. Conduit tags: 304 stainless steel, 20 gauge thickness tags with conduit number laser-engraved on tag, attached to conduit with 316 stainless steel, 18 gauge tie wire. Manufacturer: Seton or equal.

B. Conductor and cable markers:
   1. Machine printed, heat-shrink type. Manufacturer: Brady IDExpert or accepted equal.

C. Conductor Color Scheme:
   1. 480 Volt Power:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
   2. 208 Volt Power: Black and Red.
   3. 120 Volt Power:
      a. Phase: Black.
      b. Neutral: White.
   4. Field Control Wiring:
      a. 24VDC and 120VAC: Red.
   5. Internal PLC and Local Control Panel Wiring:
      a. Discrete Input 120VAC: Red.
      b. Discrete Input 24VDC: Blue.

c. Discrete Output 24VDC and 120VAC: Yellow.
6. Signal Cable:
   a. Positive Conductor: Clear.
   b. Negative Conductor: Black.
7. Communication Cable: Blue.
8. Ground: Green.

D. Conduit tagging scheme shall be based upon the circuit numbers contained within the conduit (e.g., for a conduit that contains circuit P-40MCP01, conduit tag shall be P-40MCP01; for a conduit that contains multiple circuits such as C-xxxx, C-xxxx and C-xxxx, the conduit tag shall be engraved to read “C-xxxx/xxxx/xxxx”).

E. Submittals: Submit proposed conduit tags and wire tags (in accordance with the interconnection diagram requirements specified herein) for all new conduit runs and conductors and cables provided. Additionally, submit identification materials and conductor color scheme summary table for City review and acceptance.

2.05 600 VOLT WIRE

A. General:
1. Conductors: ASTM B8, soft drawn copper, maximum 12 months old, minimum 97 percent conductivity, AWG and kcmil sizes as indicated on the Drawings, Class B.
2. Insulation thickness: Minimum specified by article 310 of the National Electrical Code, latest edition.

B. Power and control wire:
1. Insulation (all conductors): Type XHHW-2 for all conductors.
2. Multiconductor Cable Jacket: PVC. Provide single conductors for all new power and control wiring, sizes and quantities as indicated on the Drawings. Multi-conductor cables are not acceptable unless specifically identified on the Drawings with a “#/C” designation.
3. Solid conductor wire: Prohibited.
4. Single conductors and multiconductor cables shall be rated for cable tray installation where routed in cable tray as indicated on the Drawings.
5. Multi-conductor Manufacturers: Okonite-FMR Okolon TS-CPE or accepted equal.

2.06 INSTRUMENTATION CABLE

A. Analog single-pair signal cable:
1. Approved for cable tray installation in accordance with the National Electrical Code.
2. Voltage rating: 600 volts.
3. Cable type: TC.
4. Temperature rating: 90 degrees Celsius for dry locations, 75 degree Celsius for wet locations.
5. Conductors: 19-strand x 29 gauge, tinned copper.
6. Conductor insulation: Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.

7. Group shielding: Minimum 1.35 mil double-faced aluminum/synthetic polymer-backed tape overlapped to provide 100 percent coverage.
8. Drain wire: 7-strand tinned copper, 2 sizes smaller than conductor.
9. Conductor size: 16 AWG.
10. Manufacturers: Belden Cable, No. 9342 or accepted equal.

2.07 ETHERNET COMMUNICATION CABLE (COPPER)

A. Ethernet Communication Cable: Category-6, 600V rated, 4-pair, 23 AWG, copper conductors, polypropylene insulation, FRPE spline center member, inner PVC jacket, overall shield (100 percent), PVC outer jacket, suitable for industrial use in harsh environments.

B. Provide RJ-45 male connectors on each new cable end after installation of new communication cable within conduit and equipment.

C. Manufacturers: Belden 7953A or accepted equal.

2.08 MODBUS COMMUNICATION CABLE (COPPER)

A. MODBUS RS-485 Communication Cable: 120-ohm, 1-pair 22AWG (7x30) tinned copper Datalene insulation, with foil shield, 1-conductor 22AWG (7x30) tinned copper, PVC insulation, overall 65 percent tinned copper braid, PVC jacket.

B. Manufacturer: Belden 3106A (no equal).

2.09 SPLICES BETWEEN EXISTING 600 VOLT CONDUCTORS AND NEW 600 VOLT CONDUCTORS

A. Where specifically indicated on the Drawings, splices shall be provided between new and existing 600 volt conductors.

B. Proposed conductor splice locations not indicated on the Drawings shall be submitted for review and acceptance by the City. Conductor splices not accepted in writing by the City are not acceptable and shall be replaced with continuous conductors at no additional cost to the City.

C. Permanent splices shall consist of a mechanical crimp-type but splice with an overall cold-shrink tubing jacket unless otherwise indicated on the Drawings.

D. Temporary splices for conductors No. 8 AWG and larger shall be made with insulated, set-screw splice blocks, Polaris or accepted equal. Temporary splices for conductors smaller than No. 8 AWG shall be made with in-line splice kits, 3M Scotchcast, 72-N Series or accepted equal.

E. All splices shall be completely water-proof once completed and rated for prolonged submergence.

F. Provide required termination ferrules for terminating temporary DLO cable to new and existing equipment and conductors.

G. Splicing of lighting and receptacle circuit conductors shall be permitted utilizing wire nuts.

2.10 CONDUIT

A. Galvanized rigid steel: Domestic raw steel, made smooth, clean, and free of burrs and rough spots to enhance wire pulling; interior and exterior surfaces coated with solid, unbroken layer of zinc; threads hot dip galvanized after cutting; entire surface finish coated with secondary bichromate treatment applied over galvanizing to prevent oxidation; threads protected by end caps, UL6 listed.

B. Stainless Steel Conduit: Fabricated from 316 stainless steel, UL6A compliant, NEC Article 344 compliant. Manufacturers: Atkore Calbrite or accepted equal.

C. Schedule 40 PVC Conduit: 90 degrees Celsius rating, heavy-duty type.

D. Liquidtight flexible metal conduit: Grounding type, weatherproof, watertight, PVC jacket, maximum 60 inch lengths, rated for installation in a Class I, Division 2 Hazardous Location at locations indicated on the Drawings, conforming to National Electrical Code Article 350, Type LFMC.

E. Couplings, connectors, condulets, and fittings: Manufactured with the same materials and processes as corresponding conduit (e.g., provide 316 stainless steel fittings for connections to 316 stainless steel conduit).

F. Pulling Tape: Pre-lubricated type, strength as required per Contractor's accepted pulling calculations. Manufacturers: Neptco "Mule Tape", 3/4-inch rated for 2,500 pounds tensile strength or accepted equal.

G. Submittals: Product data for proposed conduit, corresponding fittings and pulling tape.

2.11 METALLIC WIREWAYS

A. Provided at locations indicated on the Drawings.

B. Fabricated from minimum 14 gauge, 316 stainless steel.

C. Enclosure rating: Where indicated on the Drawings as NEMA 4X, enclosure shall be fabricated from minimum 14-gauge 316 stainless steel. Where indicated as either NEMA 1 or NEMA 3R on the Drawings, enclosure shall be fabricated from painted 14-gauge steel, minimum.

D. Minimum dimensions: As indicated on the Drawings. Where dimensions are not indicated on the Drawings, Contractor shall provide box with minimum dimensions in accordance with National Electrical Code requirements.

E. Manufacturers: Hoffman or accepted equal.

2.12 CABLE TRAYS

A. Aluminum, ladder cable tray, heavy-duty type.

B. Tray Width: As indicated on the Drawings.

C. Manufactured in compliance with NEMA VE 1.

D. Rung Spacing: 9 inches.

E. Rail Height: Loading depth is indicated on the Drawings. Minimum side rail height shall be 5 inches.

F. Minimum Bending Radius: 12 inches.

G. Allowable Support Span: In accordance with support locations indicated on the Drawings. Where not indicated on the Drawings, support span maximum distance shall be 20 feet.

H. Provide No. 4/0 AWG copper bonding jumper and connection hardware at each cable tray straight run and fitting bolted connection joint. Manufacturer: Eaton Catalog No. 99-40 or accepted equal.

I. Cable Tray Manufacturers: Eaton B-Line, Series 35 or accepted equal.

2.13 METALLIC PULLBOXES, JUNCTION BOXES AND TERMINAL BOXES

A. Provided at locations indicated on the Drawings.

B. Where indicated on the Drawings as NEMA 4X, enclosure shall be fabricated from minimum 14-gauge 316 stainless steel. Where indicated as either NEMA 1 or NEMA 3R on the Drawings, enclosure shall be fabricated from painted 14-gauge steel, minimum.

C. Minimum dimensions: As indicated on the Drawings. Where dimensions are not indicated on the Drawings, Contractor shall provide box with minimum dimensions in accordance with National Electrical Code requirements.

D. Provide terminal boxes with internal backpan for mounting of power and grounding lugs and control terminal blocks. Terminal boxes shall be provided as a UL Listed complete assembly.

E. Manufacturers: Hoffman or accepted equal.

2.14 480 VOLT DISTRIBUTION PANELBOARDS

A. Rated 480 volts, 3-phase, 3-wire, 65,000 amperes interrupting capacity (symmetrical), continuous bus ampere rating as indicated on the Drawings.

B. Provide each panelboard with a molded-case main circuit breaker, ratings as indicated on the Drawings.

C. Feeder circuit breakers shall be molded-case, fixed-mounted, rated minimum 65,000 amperes interrupting capacity (symmetrical), continuous ampere ratings and quantities as indicated on the Drawings.

D. Circuit breakers shall comply with NEMA Standard AB1 and UL 489.

E. Main and feeder circuit breaker handle operation shall be up/down or side-to-side. Use of rotational operating handles is not acceptable.

F. Enclosure (40-PNL-11 and 40-PNL-21): NEMA Type 1, ANSI 61 Gray, suitable for indoor mounting as indicated on the Drawings.

G. Enclosure (PNL-TEMP1 and PNL-TEMP2): NEMA Type 3R, ANSI 61 Gray, suitable for mounting as indicated on the Drawings.

H. Dimensions: Minimum 60 inches high by 20 inches wide by 5.75 inches deep, suitable for feeder breaker quantities and spaces as indicated on the Drawings.

I. Phase and Grounding Bussing: Tin-plated copper.

J. Manufacturers: The following or equal:
   1. Eaton Cutler-Hammer, Power-R-Line 3a.

2.15 SWITCHBOARD SB-UV FEEDER CIRCUIT BREAKERS

A. Molded-case circuit breakers, 3-pole, trip rating as indicated on the Drawings, 65,000 amperes symmetrical interrupting rating, provided with connection lugs.

B. Manufacturer: Eaton Type HKD3225 (no equal).

2.16 FIELD-MOUNTED PILOT DEVICES

A. Manufacturers: One of the following or equal:
   1. Allen-Bradley, Bulletin 800H.
   2. General Electric – CR104P.

B. Pushbuttons and Selector Switches: Heavy-duty, industrial type, pushbuttons with lockout provisions as indicated on the Drawings, 30.5mm.

C. Pilot Lights: Lens colors as indicated on the Drawings, LED lamp, push-to-test type, 30.5 mm.

D. Enclosure Rating: NEMA 4X, 14 gauge, 316 stainless steel, rated for outdoor use.

2.17 GROUNDING

A. Grounding conductor: Stranded, bare copper, size as indicated on the Drawings.

B. Grounding rods: 10 feet minimum length, 3/4-inch diameter, copper-coated steel.

C. Grounding connections: Welded connections. Mechanical connections are not acceptable.

D. Grounding rod well: Precast concrete, round, open bottom, suitable for AASHTO H-20 traffic loading. The word "GROUND" shall be formed into top, removable concrete cover.

PART 3 EXECUTION

3.01 PREPARATION

A. Cutting and Repairing: Where it becomes necessary to cut into existing work for the purpose of making electrical installations, use core drills for making circular holes in accordance with the accepted X-ray or scan photographs. Other demolition methods for cutting or removing shall be reviewed by the City prior to starting the work.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Corrosion Protection:
   1. Isolate dissimilar metals, except conduit and conduit fittings, that may come into contact with neoprene washers, 9 mil polyethylene tape, or gaskets.
   2. Restore factory finishes which are damaged or rusted to their original new condition in accordance with manufacturer's surface preparation and coating instructions.

B. Install embedded electrical work prior to placing equipment pads. Provide all sleeves and openings through floors and walls required for passage of all conduits and other raceways. Sleeves shall be rigidly supported and suitably packed or sealed to prevent ingress of wet concrete or water.

C. Provide all insets and hangers required to support raceways and other electrical equipment.

D. Field-verify dimensions indicated on the Drawings. Actual locations, distances and levels shall be governed by actual field conditions.

E. Anchor electrical equipment to structure floors and walls and electrical equipment foundations utilizing epoxy-fastened bolts. Sizes and quantities of fasteners shall be as indicated on the Drawings unless otherwise required by the Contractor’s accepted structural calculations.

F. After installing and before energizing electrical equipment, torque each bolted bus and cable connection in accordance with manufacturer’s recommendations with calibrated torque wrenches.

G. Provide channels and associated hardware as required for support of raceways, device enclosures and other electrical equipment.

H. Separate iron or steel supports from aluminum with 1/4-inch neoprene or other non-metallic gasketing.

I. Provide engraved lamacoid nameplates to each new motor control center, new panelboards, terminal boxes, junction boxes, local control panels and local control stations. Engraving shall include equipment tag numbers and names as indicated on the Drawings.

J. Provide grounding bushings at each end of metallic conduit runs. Grounding bushings shall be bonded to the grounding electrode system.

3.03 CLEANING

A. Clean each piece of electrical equipment, existing and new, both inside and outside, and retouch equipment to match existing paint.

3.04 ELECTRICAL INDENTIFICATION

A. Wire colors: As specified herein.

B. Provide unique wire tagging at each individual conductor termination endpoint. Conductor tags shall match at each conductor endpoint. Conductor tags shall be developed in accordance with the tag numbers indicated on accepted submittal information.

C. Provide conduit tags at each conduit endpoint, at each wall penetration location and at each grade or concrete stub-up location.

D. Tag spare conduits with the word "SPARE".

3.05 CONDUCTORS

A. Provide continuous power and control circuit conductors from source to load termination locations without splices or terminations in raceway system pullboxes or junction boxes unless splices are specifically indicated on the Drawings.

B. Ethernet communication cables routed within new power distribution equipment shall be kept physically separated from 480V power conductors as is practical.

C. For existing conductors indicated on the Drawings to be disconnected and removed, should existing conductors not be capable of being removed from existing raceways following Contractor diligent efforts to remove the conductors, the conductors shall be cut off within all accessible raceway system locations, safe-off with insulating tape and tagged as “ABANDONED CONDUCTORS”.

3.06 CONDUITS

A. Install conduit runs in accordance with schematic representations indicated on the Drawings. Adjust routing of conduit runs as required to suit actual field conditions.

B. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends. Make changes in direction with long radius bends or with condulet fittings.

C. Provide flexible conduit connections for short lengths required to facilitate connections between rigid conduit and vibrating equipment and instrumentation.

D. Support conduits on walls and from ceilings utilizing mounting details indicated on the Drawings. Minimum support spacing shall be in accordance with National Electrical Code requirements unless otherwise indicated on the Drawings.

E. Install conduit runs between pullboxes, junction boxes, panels and equipment with total bends equaling not more than 270 degrees.

F. Provide pull tape in spare conduits.

G. Prior to installation of conductors, new and existing conduits 2 inches and larger shall be snaked with a cleaning mandrel.

H. Provide stainless steel conduit for installation locations listed below:
   1. All exposed, exterior conduit runs.
   2. Through structure walls (extending a minimum of 6 inches on each side of wall penetration), floor and ceiling penetrations (extending a minimum of 6 inches beyond exposed portion of ceiling and floor penetrations).
   3. Below-grade pullbox entry locations as indicated on the Drawings.
   4. Minimum 12 inches below grade for below-grade to above-grade conduit transitions.
   5. Stainless steel conduit factory sweeps shall be utilized for all conduit “turn up” locations from below-grade installations.

I. Provide galvanized rigid steel conduit for installation locations listed below:
   1. All Plant main structure interior location exposed conduit runs unless otherwise specified herein.

J. Provide Schedule 40, PVC conduit for installation locations listed below:
   1. New below-grade direct-buried conduits, conduits embedded in new concrete slabs and conduits provided in new steel-reinforced concrete electrical ductbanks.
   2. UV process area interior location exposed conduit runs and all exterior exposed conduit runs.
   3. Interior exposed conduit runs located in the Plant main structure “Mechanical Room”.
   4. Temporary UV disinfection and bypass pumping system conduits.

K. Provide flexible sealing putty at all conduit stub-up locations for conduits that originate from below grade.

L. Provide separate grounding conductor in each conduit run as indicated on the Drawings. Where not indicated on the Drawings, provide minimum size grounding conductor in accordance with National Electrical Code requirements.

3.07 BOXES

A. Where not indicated on the Drawings, size junction boxes in accordance with National Electrical Code requirements.

3.08 ELECTRICAL FIELD TESTING, POWER SYSTEM STUDIES AND EQUIPMENT CONFIGURATION

A. Electrical equipment field testing shall be performed after new equipment has been factory witness tested (as specified herein) and has been delivered to the project site.

B. Electrical conductor field testing shall be performed after new conductors have been completely installed, including splices and terminations.

C. Electrical field testing shall be performed in three stages; i) Pre-Energization Testing/Instrument Signal Loop Calibration/Testing, ii) Functional Testing and iii) Thermographic Surveying of electrical materials and equipment. Pre-energization, instrument loop calibration/testing and thermographic surveying shall be performed by an independent, third-party testing organization. Functional testing shall be performed jointly by the Contractor, City's Programmer, Engineer and City.

D. All electrical field testing shall be witnessed by the City or the City's representative.

E. All new power and molded-case circuit breakers and motor circuit protectors operating at 480 volts shall be tested, regardless of ampacity rating. New circuit breakers rated 50 amperes and larger operating at 120 volts, 208 volts or 240 volts shall be tested.

F. Short circuit, protective device coordination and arc flash system studies shall be performed by the Contractor:
   1. Contractor shall perform studies utilizing SKM Systems analysis software or ETAP analysis software (no equal).
   2. Contractor shall develop a partial power system model of the facility which includes all new and existing power system equipment and locations EXCEPT for the following:
      a. Existing automatic transfer switch ATS-2 and all conductors, equipment and loads supplied downstream of existing ATS-2 may be omitted from the developed power system software model.
      b. Existing automatic transfer switch ATS-3 and all conductors, equipment and loads supplied downstream of existing ATS-3 may be omitted from the developed power system software model.
      c. Existing automatic transfer switch ATS-4 and all conductors, equipment and loads supplied downstream of existing ATS-4 may be omitted from the developed power system software model.
   3. Software model shall include the upstream PG&E system source short circuit, impedance and protective device information.
   4. Contractor shall be responsible for requesting from the City, in writing, PG&E system short circuit and impedance data no less than six weeks prior to requiring this information for Contractor development of the system model. Once received from PG&E, the City shall provide the Contractor with the PG&E system source data. Upon receipt of this data, the Contractor shall include this information in the developed power system software model.

5. **Contractor is responsible for all field-investigation to obtain all new and existing plant power distribution system equipment nameplate data, feeder circuit lengths and power system configuration**. Existing facility documentation is limited. The Contractor shall assume in the bid that existing power system information required for partial modeling of the existing power system is not available and will need to be gathered by the Contractor via onsite system and equipment investigation.
6. Analysis scenarios shall include the following for short circuit, coordination and arc flash hazard studies, assuming all electrical loads in operation:
    a. Utility source supplying power to the facility.
    b. Standby generator sources supplying power to the facility.
7. Coordination studies and arc flash hazard studies shall be performed to provide optimal protective device coordination while minimizing arc flash hazard.
8. Submittals:
    a. Power system studies shall be stamped and signed by a Professional Electrical Engineer.
    b. Software model single line diagram.
    c. Equipment evaluation table (based on worst-case calculated short circuit values for the scenarios specified herein).
    d. Time-current coordination (TCC) curves and associated recommended protection settings for all new power system equipment, including UV system equipment and temporary UV system equipment. All existing power system equipment circuit breaker settings shall be assumed to remain unchanged with existing protective device settings, as field-verified by the Contractor, included in the power system study calculations and analysis. The study report shall include any recommended adjustments to existing equipment settings for consideration by the City.
    e. Arc flash hazard summary table for all existing and new power system buses included in the studies.
    f. Proposed arc flash hazard labels for each existing and new power system bus included in the studies for review and acceptance by the Engineer prior to printing final adhesive labels.
9. Protective device settings for all new circuit breakers, motor circuit protectors and motor overloads shall be implemented by the Contractor's testing firm prior to performing field pre-energization testing.
10. After acceptance of the power system studies by the Engineer, Contractor shall provide arc flash hazard warning labels at field locations consistent with the software study.

G. Pre-Energization Testing: The first stage of electrical field testing shall consist of electrical equipment testing and conductor testing prior to energization and operation of electrical equipment. Completed equipment and conductor testing data forms shall be submitted for City's review prior to equipment start-up and energization. Unsatisfactory equipment or conductor test results shall require that the equipment and/or conductors be repaired and re-tested until acceptable results are obtained at no additional cost to the City.

H. Loop Testing: As part of the first stage of electrical field testing, the Contractor shall perform loop testing on all new discrete and analog signal connections to verify accuracy and integrity of each signal connection. Loop testing shall be performed for all new discrete and analog field signals included as part of the UV system equipment.

I. Functional Testing: As specified in Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse.

J. Thermographic Surveying: The third stage of testing shall involve thermographic surveying of locations specified herein. Thermographic surveying shall be performed for each individual location only after the respective load has been in continuous operation at maximum possible loading conditions for no less than 30 minutes.

K. Equipment to be tested and configured as part of Pre-Energization Testing:
   1. New 480-volt panelboard PNL-TEMP1: Testing shall be performed in accordance with NETA 7.1. All 480 volt circuit breakers shall be tested in accordance with NETA 7.6.1.1 recommendations.
   2. New 480-volt panelboard PNL-TEMP2: Testing shall be performed in accordance with NETA 7.1. All 480 volt circuit breakers shall be tested in accordance with NETA 7.6.1.1 recommendations.
   3. New 480-volt panelboard 40-PNL-11: Testing shall be performed in accordance with NETA 7.1. All 480 volt circuit breakers shall be tested in accordance with NETA 7.6.1.1 recommendations.
   4. New 480-volt panelboard 40-PNL-21: Testing shall be performed in accordance with NETA 7.1. All 480 volt circuit breakers shall be tested in accordance with NETA 7.6.1.1 recommendations.
   5. Megger testing of all new power conductors No. 12AWG and larger and complete conductor runs comprised of existing conductors spliced to new conductors (testing to be performed after splices have been completed). Testing shall be performed phase-to-phase and each phase-to-ground in accordance with NETA 7.3.2 recommendations.
   6. New grounding system testing at the UV process area in accordance with NETA 7.13 recommendations.

L. Equipment to be tested as part Thermographic Surveying:
   1. New 480-volt panelboard PNL-TEMP1.
   2. New 480-volt panelboard PNL-TEMP2.
   3. New 480-volt panelboard 40-PNL-11.
   4. New 480-volt panelboard 40-PNL-21.
   5. New UV system Power Distribution Center 40-PDC-11.
   6. New UV system Power Distribution Center 40-PDC-12.
   7. New UV system Power Distribution Center 40-PDC-21.
   8. New UV system Power Distribution Center 40-PDC-22.

END OF SECTION

SECTION 31_05_15

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Material requirements for soils and aggregates.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. C535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   5. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   6. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   7. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   8. D4829 - Standard Test Method for Expansion Index of Soils.
   9. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.

B. California State Transportation Agency, Department of Transportation (CALTRANS):
   1. (Standard Specifications).
   2. California Test Methods (CTM):
      a. California Test 205 - Method of Test for Determining Crushed Particles.
      b. California Test 211 - Method of Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Abrasion Testing Machine.
      c. California Test 217 - Method of Test for Sand Equivalent.
      d. California Test 229 - Method of Test for Durability Index.
      e. California Test 301 - Method of Test for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer.

1.03 SUBMITTALS

A. Product data:
   1. Material source.

2. Gradation.
3. Testing data.

B. Quality control for aggregate base course:
1. Test reports: Reports for tests required by Sections of Standard Specifications.
2. Certificates of Compliance: Certificates as required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

B. Comply with Standard Specifications storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.

B. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

C. Comply with soil and aggregate material requirements in the Standard Specifications, unless specified otherwise.

2.02 AGGREGATE BASE COURSE

A. Material requirements:
1. Class 2, 3/4-inch maximum aggregate size, free from organic matter and other deleterious substances, and of such nature that aggregate can be compacted readily under watering and rolling to form a firm, stable base.
1. Aggregate base course for structures:
a. Consist of crushed or fragmented particles.
b. Coarse aggregate material retained in Number 4 sieve shall consist of material of which at least 25 percent by weight shall be crushed particles when tested in accordance with California Test 205.
2. Aggregate shall not be treated with lime, cement, or other chemical material.
3. Durability index: Not less than 35 when tested in accordance with California Test 229.
4. Aggregate grading and sand equivalent tests shall be performed to represent not more than 500 cubic yards or 1 day's production of material, whichever is smaller.
5. Sand equivalent: Not less than 25 when tested in accordance with California Test 217.
6. Resistance (R-value): Not less than 78 when tested in accordance with California Test 301.

7. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Sizes (Square Openings)	**Percent by Weight Passing Sieve**
1 inch	100
3/4 inch	90 - 100
Number 4	35 - 60
Number 30	10 - 30
Number 200	2 - 9

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 31_34_07

LOW DENSITY CELLULAR CONCRETE FILL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Low density cellular concrete fill (LDCCF).

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 523.1R - Guide for Cast-in-Place Low-Density Cellular Concrete.

B. ASTM International (ASTM):
   1. C495 - Standard Test Method for Compressive Strength of Lightweight Insulating Concrete.
   2. C567 - Standard Test Method for Determining Density of Structural Lightweight Concrete.
   3. C796 - Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam.
   4. C869 - Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.

1.03 SUBMITTALS

A. Mix design.

B. Cellular concrete applicator qualifications.

C. Test reports.

1.04 QUALITY ASSURANCE

A. Cellular concrete applicator qualifications:
   1. Cellular concrete applicator shall be approved by the manufacturer of the cellular concrete.
   2. Cellular concrete applicator shall be regularly engaged in the placement of cellular concrete including completion of minimum of 40,000 cubic yards in past 5 years.
      a. Cellular concrete applicator shall furnish a list of all cellular concrete projects completed in last 5 years.
      b. List shall contain the names, addresses, and telephone numbers of the references for these projects.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Elastizell Corp. of America, Elastizell EF.
   2. Aerix Industries, Aerlite.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Cellular concrete properties:
      a. Cellular concrete for UV Channel, with maximum cast density of 30 pounds per cubic foot, and with minimum compressive strength of 40 pounds per square inch.
   2. Provide cellular concrete work conforming with best standard practices, in accordance with ACI 523.1R, and recommenced practices.

2.03 MATERIALS

A. Cellular concrete components:
   1. Type II low alkali portland cement.
   2. Water as specified in Section 03_30_00 - Cast-in-Place Concrete.
   3. Foaming agent: In accordance with ASTM C869 when tested in accordance with ASTM C796.

2.04 PRE-PRODUCTION TESTING

A. Take 2 sets comprising 4 cylinders for each proposed mix and perform compressive strength tests on samples at 28 calendar days in accordance with ASTM C495.

2.05 EQUIPMENT

A. General:
   1. Furnish equipment of sufficient size to batch and pump the required volume of low-density cellular concrete as indicated on the Drawings.
   2. Maintain equipment in good operating condition and provide an adequate inventory of spare parts and backup equipment on site to ensure that equipment is available at all times.

B. Batching equipment:
   1. Utilize mechanical system of batching equipment to ensure consistency of mix.
   2. Provide digital printout record of batch scale readings, accurate to 1 pound of dry mix ingredients.

C. Foam generator:
   1. Generate foam by combining controlled quantities of air, water, and foaming agent under pressure in accordance with the foaming agent manufacturer’s recommendation.
   2. Maintain the temperature of water used in generating foam below 80 degrees Fahrenheit, or as recommended by foaming agent manufacturer.

3. Provide timer controls to repetitively discharge pre-selected quantity, or to continuously discharge at fixed rate.
4. Discharge foam into mixer and blend with cement slurry.

D. Mixing:
1. Configure mixer to be compatible with pump to ensure continuous and uniform flow at point of placement.
2. Provide mixer capable of providing super-wetted, homogenized mix.
3. Equip mixer with water meter with accuracy of within 1 gallon for measuring amount of mixing water to be added to dry mix ingredients.

E. Pumping:
1. Provide equipment capable of pumping amounts of cellular concrete to be conveyed without pulsation or segregation.
2. Operate pump to uniformly convey continuous stream of cellular concrete, without air pockets.

2.06 MIXES

A. Generate preformed foam by combining controlled quantities of air, water, and foaming agent under pressure. Foam shall retain its stability until cement sets form a self-supporting matrix.

B. Admixtures may be used to reduce water, to control set time, and to reduce washout, segregation, and bleeding. Admixtures shall be approved by foaming agent manufacturer and shall be in accordance with their recommendations.

C. Admixture content, batching method, and time of introduction to mix shall be in accordance with manufacturer’s recommendations.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Location where cellular concrete is to be placed shall be clean and free of extraneous material and running water.
2. Install cellular concrete as indicated on the Drawings and specified.
   a. After curing for 12 hours, remove any crumbling area on surface and scarified before next layer of cellular concrete is placed.
3. If ambient temperatures are anticipated to be below 40 degrees Fahrenheit within 24 hours after placement, heat mixing water when approved by manufacturer of foaming agent. If use of heated water is not approved by manufacturer of foaming agent, placement is prohibited during such period.
4. Job site batched cellular concrete mix with the foaming agent, and placed with specialized equipment certified by manufacturer.
5. Final finish surface shall be within 0.50 inch of elevations indicated on the Drawings.
6. On completion of cellular concrete placement, remove waste material, spilled grout or concrete, and construction debris from job site.

3.02 FIELD QUALITY CONTROL

A. Testing of cellular concrete:
   1. During progress of construction, Owner will have tests made to determine whether cellular concrete, as being produced, complies with specified requirements.
   2. Test cellular concrete compressive strength in accordance with ASTM C495, and mimicking in-situ pressures except:
      a. Cast cylinders using Styrofoam molds: Do not use plastic molds.
      b. Do not oven cure test specimens.
      c. Cap specimens with plaster of paris: Do not use sulfur caps.
   3. Test cellular concrete wet densities in accordance with ASTM C567.

B. Production testing:
   1. At batch plant:
      a. Test and calibrate equipment to generate foam for cellular concrete each day for density and volume output.
      b. Sample and test wet density of cellular concrete in accordance with ASTM C796 prior to introduction of the foaming agent and noting the time and temperature:
         1) Every 45 minutes.
         2) For each batch mixed.
         3) Whenever compression test cylinders are made.
   2. At placement location:
      a. Collect samples of cellular concrete at injection point or discharge point.
      b. Compressive strength tests:
         1) Take 2 sets of 2 cylinders for every 200 cubic yards batched, but no less than 2 sets per day.
         2) Test 2 cylinders at 28 days in accordance with ASTM C495, except do not oven cure test specimens.
            a) Cap test cylinders with plaster of paris. Sulfur caps are not permitted.
            b) Test additional 2 cylinders taken at 28 days.
      c. Wet density test:
         1) In accordance with ASTM C567.
         2) Sample at the connection port:
            a) Test every 30 minutes.
            b) Test after change in mix.
            c) Test whenever compressive strength test cylinders are made.
      d. Immediately cease batching and placement if mix does not meet design unit weight requirement. Take corrective actions acceptable to Engineer before continuing with batching or placement.

C. For cellular concrete with test results for strength that are not within the specified range, remove and replace with cellular concrete conforming to specifications.
   1. All works associated with removal and replacement, including any other impacts to work, shall be sole responsibility of Contractor at no additional cost to Owner.

END OF SECTION

SECTION 32_01_15

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

1.02 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

2.02 MATERIALS

A. Aggregate base course: As specified in Section 31_05_15 – Soil and for Earthwork.

B. Asphalt pavement: As specified in Section 32_12_17 - Asphaltic Concrete Paving (CA).

C. Portland cement concrete replacement material: Class A concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

2.03 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.04 ACCESSORIES

A. Material for painting asphalt concrete pavement: Tack coat as specified in Section 32_12_17 - Asphaltic Concrete Paving (CA).

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
   3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
   4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
   1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.

2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
3. Provide expansion joints that match existing.
4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
a. Provide expansion joints of same spacing and thickness as original construction.

3.02 FIELD QUALITY CONTROL

A. Tests:
1. Asphalt concrete as specified in Section 32_12_17 - Asphaltic Concrete Paving (CA).
2. Concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

B. Inspection:
1. Asphalt concrete:
a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
2. Portland cement concrete replacement pavement:
a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 32_12_17

ASPHALTIC CONCRETE PAVING (CA)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Asphalt pavement on prepared subgrade or aggregate base course to lines, grades, and compacted thickness as indicated on the Drawings.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. T 209 - Standard Method of Test for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures.

B. Caltrans Standard Test Methods:
   1. California Test 304 - Preparation of Bituminous Mixtures for Testing.
   2. California Test 362 - Determining Asphalt Content in Bituminous Mixtures by Vacuum Extraction.
   3. California Test 375 - Determining the In-Place Density and Relative Compaction of AC Pavement.
   4. California Test 382 - Determining Asphalt Content in Bituminous Mixtures (Ignition Oven Method).

C. State of California Department of Transportation Standard Specifications, latest edition (Caltrans Standard Specifications):
   1. Section 37 - Bituminous Seals.
   2. Section 39 - Asphalt Concrete.
   3. Section 92 - Asphalt Binders.
   4. Section 94 - Asphaltic Emulsions.
   5. Section 96 - Geosynthetics.

1.03 SUBMITTALS

A. Job mix formula.

B. Shop Drawings.

C. Product data:
   1. Asphalt binder.
   2. Asphalt aggregate.
   3. Pavement reinforcing fabric.
   4. Tack coat application rate calculations.

D. Quality control Submittals:
   1. Test results.
   2. Certificate of Compliance.
   3. Certificate of Competence.

E. Equipment list.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Asphalt pavement delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.

1.05 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, and when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy, when based on which material is to be placed is in wet or frozen conditions, or when, in the opinion of the Engineer, weather conditions will prevent proper handling, finishing, or compaction of the mixtures.
   2. Prime coat:
      a. Do not apply prime coat when atmospheric temperature is below 60 degrees Fahrenheit.
      b. Apply prime coat only when base course is dry or contains moisture not in excess of that which will permit uniform distribution and desired penetration.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. This Work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compaction of the mixture as specified and as indicated on the Drawings.

B. In general, asphalt concrete and asphalt concrete base shall be in accordance with to Section 39 “Asphalt Concrete,” and applicable referenced sections of the Caltrans Standard Specifications:
   1. Where conflicts exist, this Specification shall govern.

2.02 ASPHALT PAVEMENT MATERIALS

A. Asphalts:
   1. Asphalt binder: Steam-refined paving asphalt, PG 64-10, in accordance with Section 92-1.02B “Performance Grades Asphalt Binders” of the Caltrans Standard Specifications.
   2. Tack coat: Asphaltic emulsion, Grade SSA1, in accordance with Section 94 of the Caltrans Standard Specifications.

B. Asphalt aggregate:
   1. Aggregate shall be in accordance with Section 39-2.02B(4)(b) of the Caltrans Standard Specifications for Type A HMA grading:
      a. For pavement placed in multiple lifts:
         1) Aggregate for the final lift (surface layer) shall be 1/2-inch maximum, medium.
         2) Aggregate for other lifts/layers shall be 3/4-inch maximum, medium.
      b. For pavements placed in a single lift:
         1) Aggregate shall be 1/2-inch maximum, medium.
   2. Use of reclaimed asphalt pavement (RAP) in asphalt concrete and asphalt concrete base is prohibited.

C. Asphalt pavement shall be produced in a batch mixing plant, a continuous pugmill mixing plant, or dryer-drum mixing plant:
   1. Proportioning shall be in accordance with Section 39-2.01B(8)(a) of the Caltrans Standard Specifications.
   2. Mixing shall be in accordance with Section 39-2.01B(8)(a) of the Caltrans Standard Specifications.

2.03 EQUIPMENT

A. Spreading and compacting equipment:
   1. Spreading equipment shall be in accordance with Section 39-2.01C(2) and applicable referenced sections of the Caltrans Standard Specifications:
      a. Only in areas inaccessible to the machine, by approval of the Engineer, will hand spreading be permitted.
   2. Compaction equipment shall be in accordance with Section 39-2.01C(2) and applicable referenced sections of the Caltrans Standard Specifications.

2.04 SOURCE QUALITY CONTROL

A. Engineer will perform sampling and tests of materials in accordance with California Test Method Number 304 and California Test Method Number 362 or 382, as applicable. Samples will be taken from materials as delivered to the site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify surfaces and site conditions are ready to receive work. If unsatisfactory conditions exist, do not commence installation until such conditions have been corrected. Beginning application means acceptance of existing conditions.

3.02 PREPARATION

A. Protection:
   1. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials.
   2. Building and other surfaces shall be covered with paper or other protection, when required.
   3. Repair any damage caused by the Contractor's employees or operations to the satisfaction of the Engineer at no additional cost to the Owner.

B. Subgrade preparation:
   1. Immediately prior to applying prime coat or tack coat, or immediately prior to placing the asphalt pavement when prime coat or tack coat is not required, the subgrade to receive asphalt pavement shall be in accordance with the compaction requirement and elevation tolerances specified for the material involved and shall be cleaned to remove any loose or extraneous material.
   2. If the asphalt pavement is to be placed on an existing base or pavement that was not constructed as part of the contract, clean the surface by sweeping, flushing, or other means to remove loose particles of paving, dirt, and other extraneous material immediately before applying the prime coat or tack coat.

3.03 TACK COAT

A. Tack coat:
   1. A tack coat of asphaltic emulsion shall be applied to vertical surfaces of existing pavement, curbs, gutters, and construction joints in the surfacing against which additional material is to be placed, or as otherwise specified in this Section.
   2. Applied in 1 application at a rate according to Section 39-2.01A(3)(j) and residual rate requirements according to the mix design and application.

3.04 ASPHALT PAVEMENT

A. Placing materials in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided that:
   1. Asphalt paver is of such design that the material will fall into a hopper that has a movable bottom conveyor to feed and screed.
   2. Loader is constructed and operated so that substantially of the material deposited into windrows is picked up and deposited into the paving machine.
   3. Windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt pavement in the windrow to fall below 260 degrees Fahrenheit.

B. Unless lower temperatures are directed by the Engineer, asphalt concrete shall be spread, and the first coverage of initial or breakdown compaction shall be complete before the surface temperature of the mixture drops below 250 degrees Fahrenheit.
   1. Breakdown and intermediate compaction shall be completed before the surface temperature drops below 190 degrees Fahrenheit.
   2. Compaction shall be completed before the surface temperature drops below 150 degrees Fahrenheit.

C. Spread and compacted in the number of layers and of the thicknesses indicated in the following table:
   1. Thickness tolerance of within 0.1 inch is allowed for asphalt concrete.
   2. Total thickness tolerance of within 0.2 inches is allowed for asphalt concrete base.

Total Thickness Indicated on Drawings[1]	Number of Lifts	Top Layer Thickness (inches)		Next Lower Layer Thickness (inches)		Other Lower Layer Thicknesses (inches)	
		Min.	Max.	Min.	Max.	Min.	Max.
<2-3/4 inches	1	-----	-----	-----	-----	-----	-----
3 inches[2]	2	1-1/4	1-1/2	1-1/4	1-1/2	-----	-----
3-1/4 to 4-3/4 inches	2	1-3/4	2-1/4	1-3/4	3	-----	-----
>5 inches	[3]	1-3/4	2-1/4	1-3/4	3	1-3/4	4-3/4

Notes:

(1) When pavement-reinforcing fabric is shown to be placed between layers of asphalt pavement, the thickness of asphalt pavement above the pavement-reinforcing fabric shall be considered to be the "Total Thickness Indicated on the Drawings" for the purpose of spreading and compacting the asphalt pavement above the pavement-reinforcing fabric.

(2) If approved by the Engineer, 1 lift of 3 inches may be placed.

(3) At least 2 layers shall be placed if the total thickness is less than 5 inches. At least 3 layers shall be placed if the total thickness is more than 5 inches, and less than 10-1/2 inches. At least 4 layers shall be placed if the total thickness is greater than 10-1/2 inches.

D. A layer shall not be placed over another layer which exceeds 3 inches in compacted thickness until the temperature of the layer which exceeds 3 inches in compacted thickness is less than 160 degrees Fahrenheit at mid depth.

E. If the temperature of any layer drops below 140 degrees Fahrenheit, or if directed by the Engineer, apply tack coat before placing next layer.

F. Unless otherwise indicated on the Drawings, asphalt mixtures shall not be handled, spread, or windrowed in a manner that will stain the finished surface of any pavement or other improvements.

G. Completed mixture shall be deposited on the prepared subgrade at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking up, or otherwise shifting the mixture.

H. Spreading:
   1. All layers of asphalt pavement shall be spread with an asphalt paver and shall be in accordance with Section 39-2.01C and applicable referenced sections of the Caltrans Standard Specifications.
   2. At locations where the asphalt pavement is to be placed over areas inaccessible to spreading and rolling equipment, layers of asphalt pavement shall be distributed directly out of the back of the dump truck and spread by hand:
      a. Asphalt pavement spread by hand shall be compacted thoroughly to the required lines, grades, and cross-sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.

I. Compaction:
   1. Compaction of asphalt pavement shall be in accordance with Section 39-2.01C, and applicable referenced sections of the Caltrans Standard Specifications.
   2. Percent of maximum theoretical density for each layer of asphalt pavement shall be 91 to 97 percent. Theoretical maximum density to be determined using AASHTO T 209 and Caltrans Standard Specifications Section 39.

J. Segregation shall be avoided, and the surfacing shall be free of pockets of coarse or fine material. Asphalt pavement containing hardened lumps shall not be used:
   1. In areas inaccessible to paving and compacting equipment where spreading is done by hand, minimize the amount of segregation.

K. Location of longitudinal joints in the top layer will be determined by the Engineer and shall not adversely affect the quality of the finished product.

L. At locations, or as directed by the Engineer, the asphalt concrete shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

3.05 FIELD QUALITY CONTROL

A. Control the quality of Work and shall provide adequate testing to ensure compliance with these Specifications:
   1. Type and size of the samples shall be suitable to determine conformance with stability, density, thickness, and other specified requirements.
      a. Use an approved power saw or core drill for cutting samples.
      b. Furnish tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.
      c. Take a minimum of 1 sample for every 4,000 square feet of asphalt pavement placed.
   2. Where open graded friction course is to be placed, core samples shall be taken prior to friction course placement.

B. Asphalt pavement shall match the grades indicated on the Drawings and shall be completely free from unintended hollows and high spots:
   1. After completion of paving work, paving shall be flooded with water.
      a. Any ponding that results in standing water greater than 3/4 inch in depth shall be ringed with chalk.

b. Such hollows shall be corrected by removing and replacing the asphalt concrete.
c. Asphalt concrete patch shall be square and at least 1-inch thick when conforming to existing surfacing.
d. Tapering or feathering is not allowed.

C. Perform in-place density and compaction tests of the completed pavement in accordance with California Test Method Number 375, to determine compliance with the specified requirements. Submit test results to Engineer for approval.

D. Cracks, settling of surface, improper drainage, improper compaction, and sloppy connection to previously laid surfaces will be construed as improper workmanship and will not be accepted.

3.06 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least 6 hours, or until the asphalt pavement has cooled sufficiently to withstand traffic without being deformed.

3.07 WORKMANSHIP AND WARRANTY

A. Provide written warranty against defects in materials or workmanship for a period of not less than 1 year upon completion of Work.

END OF SECTION

SECTION 33_05_12

TEMPORARY BYPASS PUMPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for electrically driven temporary bypass pumps for pumping of wastewater flows on plant sites as needed to complete the Work.

B. Two temporary UV disinfection units are associated with the temporary bypass. Coordination of the pumping and disinfection submittals is required. The schedule requirements for submittal and operation of the bypass systems are outlined in Section 01_14_00 - Work Restrictions. The information for the temporary UV disinfection systems is summarized as follows:
   1. The temporary UV disinfection system from Trojan Technologies was prepurchased, and the contract is assigned to the Contractor according to Section 00_54_34 - Assignment of Procurement Contract. The current submittal from Trojan Technologies is Attachment B3 of Section 46_66_85 - Ultraviolet Disinfection System.
   2. The preselection agreement for the temporary UV disinfection system from Glasco UV is assigned to the Contractor according to Section 00_41_00 - Bid Form. The preselected proposal is included as an attachment in Section 00_41_00 - Bid Form.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

1.03 GENERAL REQUIREMENTS

A. Refer to Section 01_35_73 - Delegated Design Procedures and Section 01_50_00- Temporary Facilities and Controls for requirements for design responsibilities and additional requirements for temporary facilities.

B. Refer to Section 01_14_00 - Work Restrictions for suggested sequencing, shutdown restrictions, additional information for suggested pumping operations, and additional operational and communication contingency planning requirements.

C. Provide all necessary labor, tools, materials, and supervision to provide temporary bypass pumping and flow control in accordance with the requirements of this Section.

D. Operate and maintain bypass pumping facilities including, but not limited to, pumps, piping, valves, controls, and monitoring until the involved portion(s) of the Work have been completed to the satisfaction of the Engineer.

E. Bypassing wastewater in a way that ensures that no wastewater is allowed to leak outside of the bypass system or plant facilities. If leakage does occur, pay all fines and reimburse the Owner for all costs associated with the cleanup of the leakage, as well as costs associated with legal actions.

F. Accept responsibility for any release of wastewater and for penalties associated with bypass pumping activities, including commissioning, operating, and decommissioning of bypass pumping facilities. Contractor shall be responsible for repairing any damage or reimbursing the Owner for any regulatory fines or additional plant staff time resulting from the Contractor's failure to maintain temporary pumping.

G. Coordinate the placement of the bypass piping and pumping equipment with the Owner.

H. The means and methods of accomplishing and maintaining the temporary bypass pumping and associated facilities shall be the sole responsibility of the Contractor. Prepare and submit designs as specified in Section 01_35_73 - Delegated Design Procedures.

I. Except as otherwise specified or authorized in writing, no interruption of wastewater flow shall be permitted throughout the duration of the project. Contractor is responsible for all wastewater overflows during construction of this work and bypass operations.

J. Take precautions to prevent any potential spillage of wastewater from entering the stormwater system.

K. Temporary bypass pumping operation:
   1. Limited to the months, times, or seasons indicated, unless approved in writing by the Engineer.
   2. Continuous operation for 24 hours per day and 7 days per week is anticipated during the period of Work.

L. Continuously monitor temporary bypass pumping.

M. Provide qualified operators continuously during operation of the bypass systems.

N. Temporary bypass pumping system shall be electrically supplied from the treatment plant power distribution system as indicated on the Drawings.

O. Temporary bypass pumping system shall have a cellular-based alarm auto-dialer to alert both the Contractor and City personnel of temporary bypass pumping system alarm conditions.

P. Temporary bypass pumping system control panel shall be connected to the existing plant SCADA system via hardwired signal connections as indicated on the Drawings and as specified herein.

Q. Temporary bypass pumping system shall be flow monitored on the discharge. Flow values will be communicated to the plant SCADA and to the temporary UV units. At a minimum the following information shall be available to Plant SCADA:
   1. System ready.
   2. Pumps running/stopped.
   3. Flow rate.
   4. Temporary UV banks on/off.
   5. Water level at pumps.
   6. High and High-high level alarms.
   7. High flow alarm.

R. Programming connecting temporary bypass pumping systems to existing plant processes for alarm response including at a minimum:
   1. Closure of filter effluent valves for:
      a. Loss of temporary bypass pumping,
      b. Loss of temporary UV disinfection, and
      c. Levels at or above an operator-adjustable high level in the pumping wet well.
   2. Additional programming identified as necessary for safe, continuous operation.

S. Design and installation of isolation structures and bulkheads required to install and operate the temporary bypass system.

1.04 SUBMITTALS

A. Prepare and submit a project-specific wastewater bypass pumping plan with completed wastewater bypass pumping checklist.
   1. Be advised that the bypass plan must provide accessibility for pedestrians and vehicular traffic in accordance with Owner requirements.
   2. Prepare and submit designs as specified in Section 01_35_73 - Delegated Design Procedures.

B. Wastewater bypass pumping plan, include the following at a minimum:
   1. Capacities and sizes of pumps, standby equipment, and power requirements, if applicable.
   2. Design calculations of the system and selected equipment, including flow, TDH with static head including all friction and minor losses, pump curves showing operating range of flow and TDH at minimum, average, and peak flow.
   3. Downstream discharge plan, including discharge plan from the temporary UV units.
   4. Pipe thrust and restraint types, sizes, and locations.
   5. Temporary pipe supports and anchoring required.
   6. Plans for access to bypass pumping locations.
   7. Schedule that shows duration of temporary bypass pumping including milestones for installation, maintenance, and removal of equipment and accessories.
   8. Means and methods of installing, operating, monitoring, and maintaining the temporary bypass pumping, include confirmation that pumps will fit into and be deployed to the proposed installation location and verification from the supplier that operation is feasible.

9. Plan indicating bypass pumping line locations.
    a. Include details showing methods used to protect and identify the bypass pumping lines through the length of the bypass route.
    b. Isolation valve locations and normal positions for different operational configurations.
10. Detailed plans of a backup systems for critical operational equipment.
11. Plan addressing access for pedestrians and vehicular traffic.
12. Mechanical plan showing equipment, valves, pipe sizes and locations, pipe materials, dimensions, vehicle access (where applicable), pedestrian access (where applicable).
13. System control panel equipment including a system single line diagram, control schematic drawings, provisions for external power and signal connections, minimum 480-volt power supply requirements (i.e., supply feeder ampacity minimum rating) and written description of the control system and its' operating sequence and alarms.
14. Programming plan for plant SCADA integration and alarms for temporary operations during bypass pumping and disinfection.
15. Proposed temporary isolation structures and bulkheads, including detailed plans, installation sequencing and shutdown, structural calculations, testing plans, and any additional requirements as specified in Section 01_35_73- Delegated Design Procedures.
16. Catalog cutsheets for pumping equipment, pipe and fittings, valves.
17. Leak testing results for temporary piping, structures, and bulkheads.
18. Emergency response plan.
19. Staffing plan.
20. Spill prevention and cleanup plan.
21. Health and safety plan.

1.05 QUALITY ASSURANCE

A. Contractor's qualifications:
    1. Minimum 5 years of experience in performing substantially similar temporary bypass operations.
    2. Submit evidence of satisfactory operation of temporary bypass facilities similar to those specified in at least 3 separate projects in accordance with the specifications, including references. Similarity to be determined by proposed pumps and flow rates.

B. Fulfillment of the specified experience requirements shall be a condition of acceptance.

PART 2 PRODUCTS

2.01 CAPACITY

A. Pumps, piping and accessories: Of adequate capacity and size to handle the range of filtered wastewater flows from minimum flow to peak flow.

B. Piping, fittings, and all accessories shall withstand 1.5 times the maximum pressure.

C. Maintain sufficient on-site equipment and materials to ensure continuous and successful operation of the bypass system.
    1. Have standby pump(s) on site to provide 50 percent redundancy of the bypass system design peak flow (approximately 6 million gallons per day (mgd)).
        a. The redundant pump(s) shall be plumbed, powered, and ready for operation at all times. Where redundant pump(s) cannot be plumbed due to access restrictions, pumps shall have connection points and equipment to allow connection within 30 minutes of loss of primary pumping.
    2. Maintain on site a sufficient number of valves, tees, elbows, connections, tools, pipe plugs, piping, and other parts or system hardware to ensure immediate repair or modification of any part of the bypass system as necessary.

D. Bulkheads and other temporary water-bearing structures shall be designed as specified in Section 01_35_73 - Delegated Design Procedures using water surface elevations provided in the Drawings. The Contractor shall confirm final operational design of the temporary systems and adjust the design parameters as needed for safe and reliable operation.

2.02 BYPASS PUMPS

A. Provide a minimum of 4 pumps: 2 duty and 1 standby, and 1 jockey.
    1. Viable pumps identified during design, or equal:
        a. Rain for Rent:
            1) Duty + Standby Pumps (2+1): 8”/98 HP Sewage Submersible.
            2) Jockey Pump: DV100CE.

B. Pump capacity: Sufficient to pump the anticipated peak hour flow with the largest pump out of service. Capable of running at minimum flow rate.

C. Pumps:
    1. Packaged units with a skid base.
    2. Clean water pumps are acceptable. The process fluid is filtered effluent which does not contain large solids.

D. Pumps: Fully automatic, self-priming, close-coupled centrifugal units. Priming system will be considered if required by manufacturer submittal(s) for reliable operation.

E. Pumps shall use oil-lubricated mechanical seal.

F. Pump materials: As follows:
    1. Volute: Cast iron.
    2. Impeller: Cast iron.
    3. Pump shaft: Type 431 stainless steel.
    4. Mechanical seal faces: Silicon carbide.

G. Pump drivers: 480-V, 3-phase electric motors.
    1. Variable frequency drives (VFDs) for each pump.

H. Jockey pump(s) shall be capable of dry operation for up to 1 hour to accommodate large fluctuations in flow.

I. Maximum pump speed: Not exceeding 2,200 revolutions per minute.

J. The system shall include the following features:
   1. Variable flow rate pumping and controls based on water level in suction structure. See Drawings and Section 01_14_00 - Work Restrictions Attachment A: Bypass Contingency Plan for suggested design operational water levels and layout.
   2. Instrumentation and controls for operation and monitoring for each pump and responding to alarms to prevent overflow.
   3. Reliable operation with minimum 8 starts per hour.
   4. Auto-dialer or equivalent notification system alarm alert capability.

K. Electrical equipment, instrumentation, and accessories: Suitable for Class I Division 2 service as defined by NFPA 820 unless otherwise specified.

L. Comply with applicable air quality regulations.

M. Provide temporary bypass pumping system control panel equipment complying with the following:
   1. Control panel enclosures rated NEMA 3R for outdoor installation.
   2. Complete temporary bypass pumping system shall be supplied from one single 480-volt, 3-phase supply feeder. All requirements for temporary bypass pumping system power distribution, voltage step-down for controls, etc. shall be accomplished utilizing equipment and components included with the temporary bypass pumping system electrical and control system equipment.
   3. Temporary bypass pumping system power supply from the plant power distribution system shall be assumed to have a maximum short circuit availability of 65,000 amperes, symmetrical.
   4. Control panel equipment shall include all required components for the supply and control of temporary bypass pump equipment including motor circuit protectors, motor starters, motor overload protection, control relays, operating mode selector switches (i.e. Hand-Off-Auto), pilot lights for indication and alarms, dry contacts for remote alarm and indication connection to the plant SCADA system, programmable logic controller and corresponding human-machine interface screen (if required by temporary bypass pumping system supplier) and field wiring terminal blocks for connection of external power and control system conductors.
   5. Control panel shall include the following normally-open dry contacts for remote alarm and indication connections to the plant SCADA system:
      a. Automatic mode indication (for each temporary bypass pump and each temporary UV skid).
      b. Failure alarm (for each temporary bypass pump, each temporary UV skid, and also for the overall temporary bypass pumping system).
      c. Running indication (for each temporary bypass pump and each temporary UV skid).
      d. Level alarms at the temporary bypass pumps.
      e. Flow alarms.

2.03 BYPASS PIPING

A. Use piping rated to the requirements stated in this section for the temporary bypass pumping system.

B. Piping integrity: 0 leakage.

C. Provide sewage type air release valve at high point in piping and appropriate pipe routing and containment for discharges from valves.

D. Provide self-priming systems where air-lock may occur.

E. Provide temporary pipe crossovers where required to allow personnel and/or vehicle access.

F. Install a flow monitor on the bypass pump discharge. Flow values will be communicated to the plant SCADA, and to the temporary UV units.

G. Supports for all temporary piping and appurtenances.

2.04 TEMPORARY STRUCTURES

A. Use materials compatible with permitted discharge limits.

B. Provide components that can be deployed within the existing structure using the existing access openings.

C. After removal of any temporary structure or anchor, repair existing facility according to relevant requirements within the Contract Documents.

PART 3 EXECUTION

3.01 GENERAL

A. Notify the Owner a minimum of 45 days prior to the Work and the notify the Engineer at least 48 hours prior to bypassing or diverting flow.

B. Place pumps, generators, and other equipment on a plastic tarp to protect against spills of petroleum products used by the equipment.

C. Before taking permanent UV disinfection process out of service, verify that bypass system is fully operational and acceptable to Engineer including:
   1. Pump flow testing.
   2. Temporary UV channel operations.
   3. SCADA signal, programming, and alarm testing.

3.02 PROTECTION

A. Be responsible for all bypass flows:
   1. Inspect the entire bypass pumping and piping system for leaks or spills at a frequency of not less than 2 times per day.

2. Do not shutdown the temporary bypass system between shifts, on holidays or weekends, or during work stoppages without written permission from the Engineer.
3. Notify the Owner immediately if temporary pumping cannot be provided at any time for any reason.

B. Provide trained and qualified attendant(s) on site during construction hours until the bypassing is no longer required. The attendant(s) shall:
1. Be trained in and capable of performing pump and piping maintenance required.
2. Be trained in the upkeep, operations, and troubleshooting of the temporary UV disinfection systems. Be capable of performing temporary UV disinfection system maintenance required.
3. Have cellular phones for communication with the Contractor and the Owner in the event of emergencies.

C. Bypass pump system shall be provided with a cellular-based autodialer, programmed for automatic dial-out to both the Contractor and designated City personnel in case of either an individual pump failure or overall temporary bypass pumping system failure. Autodialer shall be provided in addition to the hardwired alarm and indication signals connected to the plant SCADA system specified herein and indicated on the drawings.
1. The same requirements for the trained and qualified attendant(s) in Part 3.02.B apply to person(s) responsible for monitoring the autodialer outside of construction hours.
2. The qualified attendant

D. No bypassing to the ground surface, receiving waters, storm drains, or bypassing which results in soil or groundwater contamination or any potential health hazards shall be permitted.
1. In the event of any wastewater spill, be responsible for the prompt cleanup and disinfecting of the spill as called for in the wastewater bypass pumping plan.
2. Compensate the Owner for the cost of any fines levied as the result of a spill or unauthorized discharge.

E. Implement measures to prevent interference between plant staff and the bypass pumping equipment, pipelines, and wastewater.

F. Take precautions to protect all bypass lines from damage.
1. Clearly identify above ground portions of the bypass lines by flashers, fencing, or other means to warn of their presence.

G. Provide and maintain necessary spare equipment and appurtenances on site to allow immediate repair and/or replacement of any pumping system component that is not functioning properly.

3.03 FIELD QUALITY CONTROL

A. Hydrostatic pressure test:
1. Prior to operation, test each section of discharge piping with maximum pressure equal to 1.5 times the maximum operating pressure.

2. Conduct test for a duration of 2 hours.
3. Test using process water or potable water as approved.
4. The line in service after test if the pressure has been maintained and there are no observable leaks.
5. Notify Engineer at least 48 hours prior to testing.

B. Inspection:
1. Inspect temporary bypass piping system at a minimum of every other hour during construction hours.
2. A qualified attendant (defined in Part 3.02.B) shall be present to monitor the operation of the bypass pumps during construction hours and will be ready to respond to an emergency event outside construction hours within 1 hour of alarm.
3. Inspection log: Keep at each pumping location.

C. Refer to Section 01_35_73 - Delegated Design Procedures and Section 01_50_00 - Temporary Facilities and Controls for additional testing and field quality control.

3.04 CLEAN-UP

A. The temporary bypass pumping system: Flush, clean and drain prior to dismantling.

B. Dispose of flushing water in approved manner.

C. Disturbed areas: Upon completion of bypass pumping operation, clean disturbed areas, restoring to original condition, including pavement restoration, at least equal to that which existed prior to start of Work.

D. Removal of all temporary anchorage and repair according to all demolition and structural requirements within the Contract Documents.

3.05 SYSTEM CONDITIONS

A. The anticipated flows are based on the plant operations. The final bypass system design shall accommodate these flows and be confirmed through the delegated design process. See Section 01_35_73 - Delegated Design Procedures for requirements.

B. System design flows (with largest pump unavailable):
1. Maximum flow: 12 mgd.
2. Average flow: 4 mgd.
3. Minimum flow: 0.25 mgd.

C. Jockey pump design flows:
1. Maximum flow: 1.5 mgd.
2. Average flow: 0.75 mgd.
3. Minimum flow: 0.25 mgd.

D. Two-duty, submersible pumps design flows:
   1. Maximum flow: 12 mgd.
   2. Minimum flow: 1.2 mgd.

E. Refer to the Section 01_14_00 - Work Restrictions Attachment A: Bypass Contingency Plan.

END OF SECTION

SECTION 40_05_00.01

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
   1. C11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe.
   2. C151 - Ductile-Iron Pipe, Centrifugally Cast.
   3. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 Inch Through 144 Inch.

C. ASTM International (ASTM):
   1. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   5. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   6. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   7. B88 - Standard Specification for Seamless Copper Water Tube.
   8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   9. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
   10. F37 - Standard Test Methods for Sealability of Gasket Materials.
   11. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

12. F594 - Standard Specification for Stainless Steel Nuts.
13. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. California Health and Safety Code.

1.03 DEFINITIONS

A. Buried Pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.

B. Exposed Pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.

C. Pipes Adjacent to a Wet Wall: Pipe centerline within 10 inches of the wet wall.

D. Underground Pipes: Buried pipes - see A. above.

E. Underwater Pipes: Pipes below the top of walls in basins or tanks containing water.

F. Wet Wall: A wall with water on at least 1 side.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials as specified in Section 01_60_00 - Product Requirements.

B. Coatings and linings requirements stated in the Pipe Schedule as modified in the individual pipe Technical Sections and Section 09_96_01 - High-Performance Coatings.

2.02 FLANGE BOLTS AND NUTS

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project:
      a. Face of the bolt shall exceed face of nut by 1/16 inch minimum.
      b. A maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey FG-1800 Anti-Seize.
         2) Weicon Anti-Seize High-Tech.

B. Steel pipe:
   1. On exposed pipes:
      a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
         1) Bolts: In accordance with ASTM A307, Grade B.
         2) Nuts: In accordance with ASTM A563, Grade A.
         3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
      b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
         1) Bolts: In accordance with ASTM A193, Grade B7.
         2) Nuts: In accordance with ASTM A194, Grade 2H.
   2. On underwater pipes and pipes adjacent to wet walls:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M.
   3. Low-temperature service: Stainless steel, Type 316:
      a. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
      b. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
      c. Washers: Alloy group matching bolts and nuts.
   4. High-temperature service or high-pressure service: Stainless steel, Type 316:
      a. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
      b. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
      c. Washers: Alloy group matching bolts and nuts.

2.03 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts including T-Bolts:
   1. High strength low alloy steel in accordance with AWWA C111.
   2. Type 304 stainless steel in accordance with ASTM F593.

B. Heavy Hex Nuts:
   1. High strength low alloy steel in accordance with AWWA C111.
   2. Type 304 stainless steel in accordance with ASTM F594.

2.04 GASKETS

A. General.
   1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.
   2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. Gaskets for flanged joints in ductile iron and steel piping for sewage service:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
   2. Gasket material:
      a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
      a. Reinforcement: Cloth or synthetic fiber.
      b. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.

3. Manufacturers: One of the following or equal:
    a. Pipe less than 48 inches in diameter:
        1) Garlock, Style 7797.
        2) John Crane, similar product.
    b. Pipe 48 inches in diameter and larger:
        1) Garlock, Style 3760.
        2) John Crane, similar product.

C. Gaskets for flanged joints in ductile iron or steel water piping:
1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
2. Material:
    a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
3. Manufacturers: One of the following or equal:
    a. Garlock, Bluegard 3300.
    b. John Crane, similar product.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Piping drawings:
    a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
    b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
        1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
2. Piping alternatives:
    a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
    b. Alternative pipe ratings:
        1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
        2) Piping of different material may not be substituted in lieu of specified piping.
    c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.

d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
    1) Manufacturer's factory trained representative:
        a) Provide on-site training for Contractor's field personnel.
        b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
    2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
e. Flanged joints: where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
2. Core drilled openings:
    a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
    b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
    c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
    a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
        1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
4. Assemble piping without distortion or stresses caused by misalignment:
    a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    b. Do not subject piping to bending or other undue stresses when fitting piping.
    c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
    d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
    e. Alter piping assembly to fit when proper fit is not obtained.
    f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Restraining above ground piping:
    1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
        a. When piping is aboveground or underwater, use mechanical or structural restraints.
        b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
    2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
        c. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

E. Connections to existing piping:
    1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
        a. Protect domestic water/potable water supplies from contamination:
            1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
            2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
    2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
    3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
    4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

F. Connections between ferrous and nonferrous metals:
    1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
    2. Nonferrous metals include aluminum, copper, and copper alloys.

G. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
    1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
    1. Upon completion of installation, clean piping interior of foreign matter and debris.
    2. Perform special cleaning when required by the Contract Documents.

B. Conduct pressure and leak test, as specified.

3.03 PIPE SCHEDULE

A. As specified in Attachment A - Pipe Schedule.

END OF SECTION

ATTACHMENT A - PIPE SCHEDULE

PIPE SCHEDULE											
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Service Conditions**	**Comments**
D	Drain										
	All	3-4	316 SST	SCH 10S	40_05_23.01 - Stainless Steel pipe	Grooved	15 feet/GR	None	None		Flanged at valves, unless noted otherwise.
CLS	Temp Chlorine Solution										
		0.5-1	PVC	SCH 80	40_05_31.14 – PVC Pipe (Pressure)	Solvent Welded	80 psig HH	None	None	Temporary service	Test existing piping prior to connecting new piping.
UW	Utility Water										
	All	2-inch	Steel	SCH 20		SCRD		EPX-M-1-PWS	EPX-M-1		

PIPE SCHEDULE											
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Service Conditions**	**Comments**

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 40_05_00.09 - Piping Systems Testing.

AM	Air method
GR	Gravity method
HH	High head method
LH	Low head method
SC	Special case

2. Abbreviations to designate piping include the following:

B&SP	Bell and spigot
BSP	Black Steel Pipe
CE	Ceramic epoxy lining
CI	Cast iron
CISP	Cast iron soil pipe
CL	Class, followed by the designation
CM	Cement mortar
CTP	Coal tar pitch
DIP	Ductile iron piping
EPP	Epoxy polyurethane coating
FL	Flange
GA	Gauge, preceded by the designation GEGrooved end joint
GL	Glass lined
GSP	Galvanized steel pipe
MJ	Mechanical joint
MWA	Mechanical wedge action
NPS	Nominal pipe size, followed by the number in inches
psi	pounds per square inch
psig	pounds per square inch gauge
PE	Polyethylene
PEE	Polyethylene encasement
PTW	Polyethylene tape wrap
PVC	Polyvinyl Chloride
RPO	Restrained push-on
SCH	Schedule, followed by the designation
SCRD	Screwed-On
SST	Stainless steel
SW	Solvent welded
VCP	Vitrified clay piping
WLD	Weld

SECTION 40_05_00.09

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01_41_00 - Regulatory Requirements, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01_50_00 - Temporary Facilities and Controls.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water at Filter Gallery Sump in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site. All requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be responsibility of Contractor.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

3.02 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) 0.1 gallons per day per inch diameter per 50 feet of piping under test.

END OF SECTION

SECTION 40_05_06.03

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.
   2. Pipe couplings for carbon steel piping.
   3. Pipe couplings for stainless steel piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 Inch Through 144 Inch.
   3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   4. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   6. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.

10. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
11. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
12. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
13. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
14. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
17. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
18. F594 - Standard Specification for Stainless Steel Nuts.
19. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data:
   1. For each product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00 - Product Requirements.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer's representative's requirements as specified in Section 01_75_17 - Commissioning and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. All other piping applications: Neoprene rubber or Buna-N.

2.02 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Grooved joint couplings:
   1. Manufacturers: The following or equal:
      a. Victaulic Co.
   2. Materials:
      a. Housings:
         1) Stainless steel in accordance with ASTM A351.
      b. Gasket: Elastomer in accordance with ASTM D2000.
      c. Bolts and nuts:
         1) Stainless steel in accordance with ASTM F593.
   3. Rigid type:
      a. Victaulic Style 489 (stainless steel housings).

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Grooved joint couplings:
   1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
   2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.

END OF SECTION

SECTION 40_05_23.01

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Stainless steel piping and tubing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
   3. B16.11 - Forged Fittings, Socket-Welded and Threaded.
   4. B31.3 - Process Piping.
   5. B36.19 - Stainless Steel Pipe.

B. American Welding Society (AWS):
   1. D1.6 - Structural Welding Code - Stainless Steel.

C. ASTM International (ASTM):
   1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
   11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. B622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
20. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. Shop drawings:
   1. Detailed layout drawings:
      a. Dimensions and alignment of pipes.
      b. Location of valves, fittings, and appurtenances.
      c. Location of field joints.
      d. Location of pipe hangars and supports.
      e. Connections to equipment and structures.
      f. Location and details of shop welds.
   2. Thickness and dimensions of fittings and gaskets.
   3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
   4. Material specifications for pipe, gaskets, fittings, and couplings.
   5. Data on joint types and components used in the system including, flanged joints, grooved joint couplings and screwed joints.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.

2.02 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Piping 3 inches in nominal diameter and greater:
      a. For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule 10S.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A778
PREN: Pitting Resistance Equivalency Number PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Piping joints:
   1. Joint types, piping greater than 2 inches in diameter, general:
      a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.

b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
    1) Welded joints.
    2) Flanged joints.
    3) Grooved joints.
c. Joints at valves and pipe appurtenances:
    1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
    2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using flanged coupling adapters or flanged joints.

    Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements as specified in Section 40_05_06.03 - Pipe Couplings.

2. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
3. Flanges for Schedule 40S and Schedule 80S pipe:
    a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
    b. Material: In accordance with ASTM A182.
4. Grooved joints:
    a. Pressure less than 500 pounds per square inch:
        1) Cut grooves from Schedule 40 or higher.
    b. Heavier schedule pipe sections used for cut groove ends:
        1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
    c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
    d. Couplings:
        1) Rigid type, cast from ductile iron, Victaulic Style 07 or equal. Galvanized finish.

F. Gaskets:
1. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.

G. Bolts for flanges:
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
    a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    b. Nuts: In accordance with ASTM A194 heavy hex pattern.

H. Fabrication of pipe sections:
1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
    a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.

b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

I. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A380 or A967.
a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.03 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
1. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Shipment to site:
1. Protect all flanges and pipe ends by encapsulating in dense foam.
2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
6. Engineer may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in such a manner as not to impart strain to connected equipment.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

3.03 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 40_05_00.01 - Common Work Results for General Piping.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.04 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 40_05_31.17

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   3. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   4. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   5. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   6. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Fittings: In accordance with ASTM D2467.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 4 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 6 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft gasket.
            a) Gasket material: As indicated on the Piping Schedule.
   3. Solvent cement:
      a. In accordance with ASTM D2564.
      b. Manufacturers: The following or equal:
         1) IPS Corp.:
            a) Primer: Type P70 or another primer certified by the manufacturer for chemical service.
            b) Cement: Type 724 or another cement certified by the manufacturer for chemical service.
      c. Certified by the manufacturer for the service of the pipe.
      d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.

2.02 SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
   1. Do not thread pipe.
   2. Do not use flanged transition fittings unless specifically indicated on the Drawings.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.

E. Solvent weld joints in accordance with ASTM D2855.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 40_05_00.01 - Common Work Results for General Piping and Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_05_51.01

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      d. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      e. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Provide vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Manuals.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.

2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 40_05_00.01 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.

c. In structures containing sewage or water, below top of walls.
d. At openings in concrete or metal decks.

2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
1. Fusion bonded epoxy:
a. Manufacturers: The following or equal:
1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
c. Apply in accordance with manufacturer's published instructions.
d. Lining thickness: 0.010 to 0.012-inch, except that:
1) Lining thickness in grooves for gaskets: 0.005-inch.
2) Do not coat seat grooves in valves with bonded seat.
e. Quality control:
1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2.04 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Valve and actuator orientation:
   1. Contractor shall coordinate with valve supplier final orientation of valve and actuator assembly based on Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
      a. Contractor shall rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
   2. Install valves with their stems in vertical position above the pipe, except as follows:
      a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
      b. Install buried plug valves with geared operators with their stems in a horizontal position.
   3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

D. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

E. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.

F. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

G. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.

2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes, or actuators:
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 40_05_52

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specialty valves.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C800 - Underground Service Line Valves and Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A536 - Standard Specification for Ductile Iron Castings.
   5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
   6. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Backflow preventer certification.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MUD VALVES

A. Manufacturers: One of the following or equal:
   1. Clow Corp., Series F-3075T.
   2. Waterman Industries, Inc., Model MV-11.

B. Design:
   1. Provide mud valves with non-rising stem.
   2. Provide standard AWWA 2-inch valve nut on stainless steel stem extension to height required.

C. Materials:
   1. Body, cover, and yoke: Cast-iron.
   2. Disc plug: Cast-iron.
   3. Seat rings: Bronze.
   4. Stem and stem nut: Bronze.
   5. Cap screws to bolt valve to cast-iron pipe flange: Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves in accordance with manufacturer's published instructions.

B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. For the following valves:
      b. Installation: 1 trip, 1 day minimum.

c. Functional Testing: 1 trips, 1 day minimum each.
d. Training:
    1) Maintenance: 2 hours per session, 2 sessions.
    2) Operations: 2 hours per session, 2 sessions.

C. Functional testing.

END OF SECTION

SECTION 40_05_57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve and gate actuators.
   2. Handwheel actuators.
   3. Hand-cranked geared actuators.
   4. Floor Boxes.
   5. Floor stands.
   6. Key operated valves.
   7. Bench stands.
   8. Accessory equipment and floor boxes.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45 - Designation System for Aluminum Finishes.

B. American Water Works Association (AWWA).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. National Electrical Code (NEC).

1.03 SUBMITTALS

A. Shop drawings: Include shop drawings and product data with associated gate or valve as an integrated unit.

1.04 QUALITY ASSURANCE

A. Provide valve actuators integral with valve or gate, except for valve actuators utilizing T-wrenches or keys, and portable gate actuators intended to operate more than 1 valve.

B. Provide similar actuators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

1.05 MAINTENANCE

A. Extra materials:
   1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

PART 2 PRODUCTS

2.01 VALVE AND GATE ACTUATORS

A. Valve actuators:
   1. Manual actuators:
      a. Material: Type 304 stainless steel.
      b. Design: Hand lever.
      c. Spring release handle: 12-inch.
      d. Notch plate: 10 position.
      e. Secure with mounting bolts.
      f. Locking device so that valve can be locked in any position with a wing nut.
   2. Stem and cover:
      a. For submerged valves, provide extension stem as indicated on the Drawings.
   3. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
      a. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
      b. Rating: Rated for 10 amps, 120 volts alternating current.
      c. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.

B. Stem covers:
   1. Aluminum pipe:
      a. Threaded cap on top.
      b. Bolted aluminum flange on bottom.
      c. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.
      d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   2. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
      a. Capped on the upper end.
      b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
      c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   3. Staff gauges:
      a. Adhesive-backed mylar, suitable for outdoor service.
      b. Calibrated in hundredths of feet.
      c. Read the weir crest elevations directly.
      d. Gauge range: 1.5 feet minimum.

e. Indicate the following elevations on each staff gauge:
   1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.
f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.

C. Stem cover flanges, pipes, and caps:
   1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
      a. A 41 - Clear Anodic Coating.
      b. C 22 - Medium Matte Finish.

D. Gate stem covers: Concentric with stem.

E. Position indicators:
   1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
   2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

F. Manual or power actuator size:
   1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.

I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.

K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.

L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.02 HANDWHEEL ACTUATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Coating: Handwheel as specified in Section 09_96_01 - High-Performance Coatings.

C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

D. Bearings above and below finished threaded bronze operating nut: Ball or roller.

E. Wheel diameter: Minimum 24 inches.

F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

I. Grease fittings: Suitable for lubrication of bearings.

2.03 HAND-CRANKED GEARED ACTUATORS

A. Type: Single removable crank; fully enclosed.

B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

C. Operating nut: When scheduled for portable gate actuators.

D. Geared lifts: Single speed with minimum ratio of 2 to 1.

E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.

F. Lift nuts: Cast manganese bronze.

G. Exterior surfaces on cast-iron lift parts: Smooth.

H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.

J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
   1. Revolving brass sleeves.
   2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
   3. Cast manganese bronze lift nuts.
   4. Cast-iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

2.04 ACCESSORY EQUIPMENT

A. Wall brackets or haunches: As indicated on the Drawings.

B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.

E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.

F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.

G. Fasteners: Type 316 stainless steel.

H. Anchor bolts: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry except that the material shall be Type 316 stainless steel.

I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.

K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.02 SCHEDULES

A. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.

B. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION

SECTION 40_05_63

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

2.02 METAL BODY BALL VALVES – FULL PORT (BAV00)

A. Metal body ball valves, less than 6-inch size:
   1. Manufacturers: One of the following, or equal:
      a. Conbraco Industries, Inc., Apollo Valves.
      b. Flow-Tek, Inc.
      c. Metso Automation/Jamesbury.
      d. NIBCO, Inc.
   2. General:
      a. Type: Non-lubricated, full port and capable of sealing in either direction.
      b. End connections:
         1) Threaded or solder ends for sizes 3-inch and smaller.
         2) Class 150 flanged for sizes larger than 3 inches.
            a) Flanges: In accordance with ASME B16.1 standards.
      c. Stem packing: Manually adjustable while valve is under pressure.
      d. Shafts:
         1) Rigidly connected to the ball by a positive means.
            a) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
      e. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
      f. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
   3. Materials:
      a. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 40_05_00.01 - Common Work Results for General Piping.
      b. Ball: Type 304 or 316 stainless steel.
      c. Seats: PTFE.
      d. Stem seals: PTFE.
      e. Bearings: Self-lubricated, corrosion resistant material.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_61_11

CONTROL SYSTEM REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Control system requirements.

B. Related sections:
   1. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   2. The following Sections are related to the Work described in this Section.
      a. Section 01_14_00 - Work Restrictions.
      b. Section 01_33_00 - Submittal Procedures.
      c. Section 01_45_00 - Quality Control.
      d. Section 01_50_00 - Temporary Facilities and Controls.
      e. Section 01_78_24 - Operation and Maintenance Manuals.
      f. Section 26_00_10 - Electrical Requirements.
      g. Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse.

C. Overview of Electrical Work:
   1. See Section 01_14_00 - Work Restrictions for additional control system requirements. Section 01_14_00 - Work Restrictions includes a proposed, sequential work procedure, equipment shutdown constraints and a description of temporary system power requirements. The requirements of Section 01_14_00 - Work Restrictions are intended to complement control system requirements specified in this Section and indicated on the Drawings.
   2. See Section 26_00_10 - Electrical Requirements for additional requirements related to the electrical system.
   3. See Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse for new UV system control and field instrumentation requirements.
   4. The Work shall include control system improvements in several areas within the existing facility including, but not limited to, the following:
      a. Connection of control system conductors to existing Plant control system equipment.
      b. Programming modifications to existing Plant programmable logic controller (PLC) equipment.
      c. Programming modifications to existing Plant SCADA system programming and graphics.
      d. Provide all other miscellaneous equipment and materials as shown and specified in the Contract Documents
   5. Programming of new ultraviolet disinfection (UV) equipment PLCs shall be performed by the UV equipment supplier as specified in Section 46_66_85 - Ultraviolet Disinfection System: Open Channel Wastewater/Reuse.

6. Programming of existing Plant PLC equipment and programming modifications to the plant SCADA system shall be performed by the Contractor's Programmer. The Contractor shall coordinate scheduling with the UV equipment supplier for programming work. The Contractor's project completion schedule shall include separate activity entries for UV system and Plant PLC and SCADA system programming, start-up and testing as specified herein.
7. Programming modifications to the plant SCADA system for monitoring of the temporary UV disinfection system shall be performed by the Contractor's Programmer. The Contractor shall coordinate scheduling with the temporary UV equipment supplier and other temporary equipment suppliers for programming work. The Contractor's project completion schedule shall include separate activity entries for temporary UV system and Plant PLC and SCADA system programming, start-up and testing as specified in Section 33_05_12 – Temporary Bypass Pumping and Section 46_66_75 – Temporary Ultraviolet Disinfection System of the Pre-Procurement Agreement.
8. Pre-Selected Plant PLC and SCADA System Programmer: Telstar Instruments.
9. Work shall be performed sequentially as specified in Section 01_14_00 - Work Restrictions and shall be closely coordinated and sequenced with overall project work.

1.02 GENERAL CONTROL SYSTEM REQUIREMENTS

A. Provide a tested and working control system as indicated in the Contract Documents. System includes all items not specifically mentioned in these Specifications or indicated on the Drawings or accepted Shop Drawings, but which are obviously necessary to make a complete and working installation, and shall be deemed to be included herein.

B. Immediately notify City, in writing, of discrepancies within the Contract Documents and discrepancies between the Contract Documents and actual field conditions.

C. Temporary Utilities:
   1. Provide and maintain temporary utilities in accordance with Section 01_50_00 - Temporary Facilities and Controls.
   2. Install temporary wiring in as indicated on the Drawings and in accordance with NEC Article 590 with Type SOOW (SO cord) portable cable and diesel locomotive cable (DLO cable), watertight connections, and ground fault interrupting equipment. After construction is completed, remove all temporary systems.
   3. Temporary SO cord shall be rated 600 volts, 90 degrees Celsius, black jacket, NEC rated Extra-Hard Usage, RoHS Compliant, UL listed. Manufacturer shall be Southwire or accepted equal.
   4. Temporary utilities and installations shall be provided in a manner which does not impede normal facility access, operation, and maintenance.
   5. Additional temporary electrical conductors and installations not indicated on the Contract Documents but required during the course of the Work shall be provided in accordance with Section 01_50_00 - Temporary Facilities and Controls.

1.03 PERFORMANCE REQUIREMENTS

A. Operate control system equipment successfully in all control modes, without failure, as required by the Contract Documents.

1.04 SUBMITTALS

A. See Section 01_33_00 - Submittal Procedures for additional requirements.

B. Product Data: Include catalog data for all new control system equipment and components specified herein and indicated on the Drawings. Catalog data shall be “arrowed” to indicate exact proposed sizes, catalog numbers, etc. for each item.

C. Custom integration drawings and interconnection diagrams: As specified in Section 26_00_10 - Electrical Requirements.

D. Project Record Documents: As specified in Section 26_00_10 - Electrical Requirements.

E. Acceptance Testing Information and Documents: Testing shall be performed in accordance with the requirements specified in Section 01_45_00 - Quality Control and as specified herein:
   1. Prior to field loop testing, blank testing forms shall be submitted for review and acceptance by the City. Field loop testing forms shall include each input/output signal connected to new UV system PLC and new connections to existing PLC equipment.
   2. Completed loop testing forms which verify signal loop continuity from each field-mounted piece of equipment, instrument, or device to new and existing PLC equipment.
   3. Calibration forms for new field-mounted instrumentation.

F. Operation and Maintenance Data: Submit in accordance with Section 01_78_24 - Operation and Maintenance Manuals and as specified herein.

1.05 QUALITY ASSURANCE

A. Regulations and Codes: Perform electrical work, including connection to electrical equipment integral with mechanical equipment, in accordance with latest published requirements of the following codes and code/standard making organizations:
   1. American National Standards Institute (ANSI).
   2. American Society for Testing and Materials (ASTM).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. Insulated Cable Engineers Association (ICEA).
   5. International Society of Automation (ISA).
   6. National Electrical Code (NEC).
   7. National Electrical Contractors Association (NECA).
   8. National Electrical Safety Code (NESC).
   9. National Electrical Manufacturers Association (NEMA).
   10. InterNational Electrical Testing Association (NETA).
   11. National Fire Protection Association (NFPA).
   12. State and local codes.

B. Materials and equipment used in performance of electrical work shall be listed or labeled by Underwriter's Laboratories (UL) for the class of service intended. Custom-integrated equipment (i.e., switchboards, new motor control centers and programmable logic controller panels) shall include a UL label indicating that the complete, integrated equipment meets applicable UL requirements.

C. Quality control shall be in accordance with the requirements specified in Section 01_45_00 - Quality Control.

PART 2 PRODUCTS

2.01 NAMEPLATES

A. As specified in Section 26_00_10 - Electrical Requirements.

2.02 CONDUIT AND CONDUCTOR IDENTIFICATION

A. As specified in Section 26_00_10 - Electrical Requirements.

2.03 600 VOLT INTERNAL PLC PANEL WIRE

A. General:
   1. Conductors: ASTM B8, soft drawn copper, maximum 12 months old, minimum 97 percent conductivity, AWG sizes as specified herein, Class B stranded.
   2. Insulation thickness: Minimum specified by article 310 of the National Electrical Code, latest edition.

B. Power and control wire:
   1. Insulation: Type MTW for all conductors routed entirely within new and existing PLC panels.
   2. Provide single conductors for new power and control wiring, sizes and quantities as indicated on the Drawings.
   3. Solid conductor wire: Prohibited.

2.04 INSTRUMENTATION CABLE

A. As specified in Section 26_00_10 - Electrical Requirements.

2.05 ETHERNET COMMUNICATION CABLE (COPPER)

A. As specified in Section 26_00_10 - Electrical Requirements.

2.06 MODBUS COMMUNICATION CABLE (COPPER)

A. As specified in Section 26_00_10 - Electrical Requirements.

PART 3 EXECUTION

3.01 CLEANING

A. Clean each piece of electrical equipment, existing and new, both inside and outside, and retouch equipment to match existing paint.

3.02 ELECTRICAL INDENTIFICATION

A. Wire colors: As specified in Section 26_00_10 - Electrical Requirements.

B. Provide unique wire tagging at each individual conductor termination endpoint. Conductor tags shall match at each conductor endpoint. Conductor tags shall be developed in accordance with the tag numbers indicated on accepted submittal information.

3.03 CONDUCTORS

A. Provide continuous power, control, and signal circuit conductors from source to load termination locations without splices or terminations in raceway system pullboxes or junction boxes unless splices are specifically indicated on the Drawings.

B. Ethernet communication cables routed within new power distribution equipment shall be kept physically separated from 480V power conductors as is practical.

3.04 CONTROL SYSTEM TESTING

A. After each new UV system integrated PLC system is installed at the project site, energized and connected to new field signal wiring and after all new field signal wiring has been connected to existing Plant PLC equipment, the Contractor shall perform loop testing for each input/output signal point. Loop testing shall be witnessed by the City. Where possible, the Contractor shall simulate input/output signal state changes at the field device location. All field loop testing shall be witnessed by the City.

B. After new PLC programming has been downloaded by Contractor's Programmer for each existing PLC location and after new PLC programming has been downloaded by the UV system supplier, the Contractor shall assist with system functional testing for each new and existing PLC system. The Contractor shall be present during all system functional testing and provide support as needed to simulate field signal state changes and assist with wiring troubleshooting. All field functional testing shall be witnessed by the City.

END OF SECTION

SECTION 41_22_17

PORTABLE DAVIT CRANES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Portable davit cranes with associated appurtenances.

1.02 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.

B. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Product data:
   1. Dimensional drawings or other construction details including materials of construction, equipment weights and equipment finishes.
   2. Manufacturer's installation instructions.

D. Operation and maintenance manuals:
   1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00 - Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment.

B. Provide davit cranes as specified in Table 1 and as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design davit crane in accordance with the Codes of the Steel Construction Manual.

Table 1. Davit Crane Requirements

Tag No	Maximum Load, pounds	Maximum Hook			Adjustable Boom Length	Mount Type
		Reach (inches)	Height above floor (inches)	Lift below floor (feet)		
40-CRN-11	500	36	90	2	22”-48”	Socket

2.03 MANUFACTURERS

A. Manufacturers: The following or equal:
   1. Thern, Model 5PA10S-M3.

2.04 PORTABLE DAVIT CRANES

A. Boom to be capable of rotating 360 degrees under load.

B. Boom to be capable of telescoping to 4 different lengths allowing the extension of the reach of the crane and the hook over the load. Boom to lock in place at each position with a locking pin.

C. Locking pin adjustment: Boom angle to be vertically adjustable. Boom to lock in place at each position with a locking pin.

D. Provide a locking device to prevent boom swivel when desired.

E. Loads are lifted with a spur gear hand winch attached to the boom and equipped with a disk brake for load control.

F. Steel gear covers protect gears and help prevent injuries.

G. Crane and base to be constructed of stainless steel.

2.05 ACCESSORIES

A. Provide 1/4 inch by 28 foot stainless steel cable with swivel hook. The hoisting cable shall be specifically designed for service loads specified:
   1. Manufacturers: The following or equal:
      a. Thern, Model WS31-28DS.

B. Provide mounting bases by the same manufacturer as the davit crane:
   1. Provide stainless steel base cover to keep water from collecting in base when crane is removed.

PART 3 EXECUTION

3.01 GENERAL

A. Crane shall not be used by Contractor for the installation of equipment.

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 FIELD QUALITY CONTROL

A. After installation, test the crane to its rated capacity:
   1. Load and slings shall be provided by the crane manufacturer and removed when tests are complete.
   2. Operate the crane through 3 complete lift and lowering cycles.

END OF SECTION