

SECTION 09 96 23

GRAFFITI RESISTANT COATING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section consists of the Contractor furnishing all materials, labor, and equipment necessary and incidental to surface preparation, furnishing, and application of a clear graffiti-resistant coating to all exposed surfaces of accessible concrete, masonry, platform canopy steel, and porous surfaces. Graffiti-resistant coating shall be applied from finish grade or floor to 10 feet above finish grade or floor and at other locations to the extents as shown on the contract drawings.

1.02 REFERENCE STANDARDS

- A. ASTM - American Society for Testing and Materials

1.03 SUBMITTALS

- A. Materials: Copies of a manufacturer's data.
- B. Samples: 24-inch square samples of coating applied to same substrates as the Work. Coat one half of each sample and identify the coated side.
- C. Certification: Duplicate copies of manufacturer's affidavit with each shipment of materials delivered to the jobsite certifying that material furnished complies with specified requirements.
- D. Manufacturer's Instructions: Copies of the manufacturer's instructions for graffiti removal and maintenance.

1.04 QUALITY CONTROL AND QUALITY ASSURANCE

Sample panel:

- A. Apply sample finish, approximately 10-sq. ft., to areas an exposed concrete surface, as directed by the Engineer.
- B. Obtain the Engineer's approval of the sample panel before proceeding further. Approved sample panel shall be used as a standard for the Work and if properly identified may remain a part of the Work.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Materials shall be stored and handled in accordance with manufacturer's recommendations.

1.06 JOB CONDITIONS

- A. Environmental requirements:
 - 1. Compliance with air quality regulations: VOC of coatings used for the Work shall not exceed limits prescribed by law.
 - 2. Comply with coating manufacturer's recommendations for environmental conditions regarding coating application.
 - 3. Do not apply finish in areas where dust is being generated.
 - 4. Provide drop cloths, shields, barricades, and other protection necessary to safeguard adjacent surfaces not to be coated.
 - 5. Provide and maintain protection as required to protect finished work from damage until its acceptance.

1.07 MAINTENANCE

- A. With closeout submittals deliver one identified unopened gallon container of graffiti- resistant coating and a 5-gallon container of cleaner to be used for graffiti removal to the Engineer. Label container with material type and area where used for future identification.
- B. Provide the Engineer with a copy of instructions for graffiti removal and maintenance recommendations.

PART 2 - PRODUCTS**2.01 DESCRIPTION**

- A. Sacrificial: SC-1 or SC-1X by ProSoCo, or approved equivalent as approved by the Engineer.

PART 3 – EXECUTION**3.01 INSPECTION**

- A. Examine surfaces to be coated for conditions that would adversely affect the permanence and quality of this work. Make sure that unsuitable conditions are corrected before proceeding with painting.

3.02 SURFACE PREPARATION

- A. Prepare surfaces to receive the coating in compliance with the manufacturer's printed instructions.

3.03 COATING PREPARATION

- A. Open containers only as required for use. Mix coating in non-environmentally protected areas.
- B. Thoroughly stir and agitate coating to uniformly smooth consistency suitable for proper application.
- C. Do not reduce, change, or use any materials except in compliance with manufacturer's printed instructions.
- D. In all cases, prepare and handle coating to prevent deterioration and inclusion of foreign matter.

3.04 APPLICATION

- A. Test coating on each type of substrate for compatibility and desired results before proceeding further.
- B. Apply coating only under conditions that will insure finishes free from blemishes and defects.
- C. Remove spillage and spatters on adjacent surfaces so as not to damage the surface being cleaned.
- D. Completed work shall match approved samples as determined by the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.

END OF SECTION

SECTION 10 14 53

ROADWAY SIGNS

PART 1 – GENERAL

1.01 DESCRIPTION

- A. Section Includes:
 - 1. Traffic signs.
 - 2. Accessories including but not limited to frames, brackets, supports, sign posts, cabinets, connectors, fasteners, and anchors.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 01 – General Requirements.
 - 2. Section 01 33 00 – Submittal Procedures.
 - 3. Section 01 60 00 – Product Requirements

1.02 REFERENCES

- A. City of Anaheim Department of Public Works:
 - 1. Current edition of the Standard Specifications for Public Works Construction (SSPWC) and associated City of Anaheim Standard Specification Supplement to the SSPWC.
 - 2. City of Anaheim Department of Public Works – Standard Plans and Details
- B. California Department of Transportation (Caltrans) Standard Specifications:
 - 1. Section 7-1.02K(6)(b) Excavation Safety
 - 2. Section 7-1.04 Public Safety
 - 3. Section 12-3.05 Channelizers
 - 4. Section 12-3.11 Construction Area Signs
 - 5. Section 12-3.30 Flashing Arrow Signs
 - 6. Section 12-3.32 Portable Changeable Message Signs
 - 7. Section 82-2.02 Materials (Signs and Markers)
- C. American Institute of Steel Construction (AISC):
 - 1. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges, Section 10, Architecturally Exposed Structural Steel.

D. ASTM International (formerly American Society for Testing and Materials):

1. A36 (A36M) – Standard Specification for Carbon Structural Steel.
2. A53 (A53M) – Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless.
3. A123 (A123M) – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
4. A153 (A153M) – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
5. A240 (A240M) – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
6. A307 – Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
7. A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
8. A501 – Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
9. A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
10. A780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
11. B209 – Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate.
12. B221 – Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
13. B429 (B429M) – Standard Specification for Aluminum Alloy Extruded Structural Pipe and Tube.
14. B633 – Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

E. American Welding Society (AWS):

1. D1.1 – Structural Welding Code – Steel.

F. CE – U.S. Army Corps of Engineers:

1. CE CRD-C621 – Standard Specification for Packaged, Dry, Hydraulic-Cement Grout (Non-shrink).
- G. Society for Protective Coatings (SSPC):
1. Paint 20 – Specification for Zinc Rich Primers (Type I, Inorganic, and Type II, Organic)
 2. SP 6 – Commercial Blast Cleaning

1.03 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00: Submittal Procedures.
- B. Product Data: Technical product specifications, anchor details and installation instructions for products used in metal fabrication, including paint products, hinges, locks, fasteners, light fixtures, and other components of work.
- C. Coating Systems:
1. Include finish manufacturer's technical information such as basic materials analysis and installation instructions.
 2. List each material and cross-reference to the specific coating, finish system and application.
 3. Identify by manufacturer's catalog number and general classification.
- D. Shop Drawings:
1. Submit Shop Drawings for fabrication and erection indicating all materials, sizes, configurations and required location of connections, junction boxes, and equipment provided under other Sections.
 - a. Include plans, elevations, details, sections, and connections.
 - b. Show anchorage and accessory items.
 - c. For structural elements, show fabrication and erection tolerances.
 2. For structural elements, include details of cuts, connections, camber, holes, and other pertinent data.
 - a. Indicate welds by standard AWS symbols, and show size, length, and type of each weld.
 3. Provide setting Plans, templates, and directions for the installation of anchor bolts and other anchorages to be installed by others.
 4. For connections designed by the fabricator as a part of fabricator's preparation of Shop Drawings, show stamp and signature of a structural engineer registered in California.

5. Show approval of lighting supplier for all illuminated signs.
 6. Include porcelain enameled steel panels, indicating method and sequencing of attachment.
 7. Equipment Provided by Others: Show all equipment and accessory items provided by OCTA or provided under other contracts.
- E. Samples: Representative samples of materials and finished products.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide work required under this section from sign manufacturers regularly engaged in work of this magnitude and scope for minimum of five years.
- B. Qualifications for Welding Work: Qualify welding processes and welding operators in accordance with the AWS Standard Qualification Procedure.
- C. Uniformity of Manufacture: For each component and process indicated, furnish products of a single manufacturer.
- D. Notify Engineer 15 days prior to 90 percent completion of the shop fabrication, so that the work may be observed prior to delivery to job site.
 1. Where fabrication is done more than 100 miles (160 kilometers) from job site, allow 14 days for observation and review before fabrication and installation of additional units.

1.05 PROJECT CONDITIONS

- A. Take field measurements prior to preparation of Shop Drawings and fabrication, where possible.
- B. Do not delay job progress; allow for trimming and fitting wherever taking field measurements before fabrication might delay work.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect sign units during transportation to OCTA by wrapping all sign units individually in soft, nonabrasive material.
- B. Pay special attention to protection of sign faces with artwork and to porcelain enamel finish.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Where products or manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Product Requirements.

2.02 MATERIALS

- A. Provide metal work composed of metals of the forms and types which comply with requirements of referenced standards and which are free from surface blemishes where exposed to view in the finished unit.
 - 1. Exposed to view surfaces exhibiting pitting, seam marks, roller marks, "oil canning," stains, discolorations, or other imperfections on finished units are not acceptable.
- B. Stainless Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304.
- C. Aluminum: Alloy and temper recommended by aluminum producer or finisher for type of use and finish indicated, and with minimum strength and durability properties of alloy and temper designated for each aluminum form required:
 - 1. Sheets: ASTM B209, 5052-H32, panel quality, thickness as indicated on Plans.
 - 2. Extruded Pipe and Tube: ASTM B429 (B429M), 6063-T6.
 - 3. Extruded Bar and Shapes: ASTM B221, 6063-T6.
 - 4. Plate and Sheet: ASTM B209, 6061-T6.
- D. Steel Plates, Shapes, and Bars: ASTM A36 (A36M).
- E. Galvanizing: G60 (Z180) zinc coating for steel fabrications; where zinc coating is reduced below average thickness required by applicable standard referenced above, apply galvanizing repair paint as specified.
 - 1. Preparation for Shop Finishing: After galvanizing, thoroughly clean ornamental metalwork of grease, dirt, oil, flux and other foreign matter, and treat with metallic phosphate process.
- F. Fasteners: Provide Type 304 or 316 stainless steel fasteners for exterior use and zinc plated fasteners with coating complying with ASTM B633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
 - 1. Do not use metals which are corrosive or otherwise incompatible with metals joined.
 - 2. Provide tamper resistant fasteners where exposed to view.
 - 3. Provide concealed fasteners for interconnection of metal work components and for attachment to other work except where exposed fasteners are or are unavoidable.

- G. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as recommended by producer of metal to be welded, complying with applicable AWS Specifications, and as required for color match, strength and compatibility in the fabricated items.
- H. Anchors and Inserts: Provide anchors of type, size, and material required for type of loading and installation condition shown, as recommended by manufacturer, unless otherwise indicated.
 - 1. Use nonferrous metal or hot dipped galvanized anchors and inserts for exterior locations and elsewhere as required for corrosion resistance.
 - 2. Use toothed steel or expansion bolt devices for drilled-in-place anchors.
- I. Very High Bond (VHB) Adhesive: VHB adhesives recommended by manufacturer.
- J. Nonshrink, Nonmetallic Grout: Premixed, factory packaged, nonstaining, noncorrosive, nongaseous, gypsum free grout complying with CE CRD-C621.
 - 1. Provide grout specifically recommended by manufacturer for interior and exterior applications as indicated on Plans.
- K. Galvanizing Repair Paint: High zinc dust content paint for regalvanizing welds in steel, complying with SSPC-Paint 20; two-component, moisture-cured urethane, zinc-rich.
 - 1. Basis of Design: Tnemec-Zinc 90-97, Tnemec Company, Inc.
 - 2. Manufacturers: Subject to compliance with requirements, provide the indicated product, a comparable product by one of the following, or equivalent approved as a substitution:
 - a. Tnemec Company, Inc.
 - b. Keeler & Long, div. PPG Industries.
 - c. International Protective Coatings, Div. International Paint.
- L. Traffic Signs: Minimum 0.067 inch thick (aka 14 gauge) sheet steel and reflectorized porcelain white beaded background and black lettering; size required by sign type and Caltrans Standard Specifications Section 56-2.
 - 1. Post Mounted: 2 inch by 2 inch by 1/8 inch (50 mm by 50 mm by 3 mm) galvanized steel pipe complying with ASTM A53; theft proof fasteners; set in concrete footing.

2.03 FABRICATION

- A. Use materials of size and thickness indicated or as required to produce strength and durability in finished product for use intended.

1. Work to dimensions shown or accepted on Shop Drawings, using proven details of fabrication and support.
 2. Use types of materials shown or specified for various components of work.
 3. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible.
 - a. Use exposed fasteners of type shown.
 4. Provide anchorage of type shown, coordinated with supporting structure. Fabricate and space anchoring devices to provide adequate support for intended use.
 5. Cut, reinforce, drill and tap miscellaneous metal work as indicated to receive finish hardware and similar items.
 6. Fabricate units to configurations indicated on reviewed Shop Drawings.
 7. Properly mark and match mark materials for field assembly.
 - a. Fabricate for delivery sequence which will expedite erection and minimize field handling of materials.
 8. Cut, fit, and assemble units with exposed surfaces smooth and square, free of cutting marks, shear distortion, burrs and nicks.
 9. Form exposed work true to line and level with accurate angles, surfaces, and edges.
 - a. Ease exposed edges to radius of approximately 1/32 inch (0.8 mm) unless otherwise shown.
 - b. Form bent metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
 10. Form simple and compound curves by bending members in jigs or other system to produce uniform curvature for each repetitive configuration required.
 - a. Maintain profile of member throughout entire bend without buckling, twisting, or otherwise deforming exposed surfaces.
- B. Steel Fabrication: Fabricate with special care using material selected for best appearance, in accordance with AISC specifications and as indicated on final Shop Drawings.
1. Apply necessary fabricating techniques to produce and maintain the quality of work within required tolerances.

2. Fabrication Tolerances: As specified in AISC Code, Section 10, Architecturally Exposed Structural Steel, unless more stringent requirements are indicated.
 3. Hot-dip galvanize after fabrication.
- C. Aluminum Fabrication: Allow for thermal movement in the design, fabrication, and installation of installed metal assemblies to prevent buckling, opening up of joints and over stressing of welds and fasteners.
1. Base design calculations on actual surface temperatures of metals due to both solar heat gain and night time sky heat loss.
 2. Provide necessary rebates, lugs, and brackets for assembly of units.
 - a. Use concealed fasteners wherever possible.
 3. Mill joints to a tight, hairline fit. Cope or miter corner joints.
 - a. Form joints exposed to weather to exclude water penetration.
 4. Finish exposed surfaces to smooth, sharp, well-defined lines and arises.
- D. Welded Construction: Comply with AWS Code for procedures, appearance, and quality of welds, and methods used in correcting welding work.
1. Select weld sizes, sequence and equipment to limit distortions to allowable tolerances.
 - a. Surface bleed of back side welding on exposed surfaces will not be acceptable.
 2. Assemble and weld by methods that produce true alignment of axes without warp.
 - a. Grind smooth exposed fillet welds; grind butt welds flush and smooth; dress all exposed welds, feather edges onto base material and polish as required for smooth painted surfaces.
 3. Provide shapes and sizes as required for profiles shown.
 - a. Fabricate units from structural steel or aluminum shapes, plates, and bars, with continuously welded joints and smooth exposed edges.
 - b. Use concealed field splices wherever possible.
 - c. Provide cutouts, fittings, and anchorages as required for coordination of assembly and installation with other work.
 4. Furnish bent or otherwise custom fabricated bolts, plates, anchors, hangers, dowels, and miscellaneous steel and iron shapes as required for supporting of signs.

5. Fabricate items of sizes, shapes, and dimensions required.
6. Weld corners and seams continuously, complying with AWS recommendations.
 - a. All exposed welds to be clean, consistent and uniform in appearance.
 - b. Grind exposed welds to match adjacent contours and finish to match adjacent finish.
- E. Holes for Other Work: Provide holes required for securing other work to sign supports, brackets and frames, and for passage of other work through metal members as shown on approved Shop Drawings.
 1. Provide threaded nuts welded to framing, and other specialty items as shown to receive other work.
 2. Drill holes 1/16 inch (1.6 mm) oversize for field alignment and fitting.
 3. Cut, drill or punch holes perpendicular to metal surfaces.
 4. Do not flame cut holes or enlarge holes by burning.
- F. Bearing Plates: Provide bearing plates for steel items bearing on concrete construction, made flat, free from warps or twists, and of required thickness and bearing area.
 1. Drill plates to receive anchor bolts and for grouting as required.
- G. Furnish inserts and anchoring devices which must be set in concrete for installation of metal work. Coordinate delivery with other work to avoid delay.
- H. Surface Preparation: After inspection and before finishing, remove loose rust, mill scale, and deposits of spatter, slag, or flux.
 1. Clean steel and aluminum by wheel abrader process or other method to achieve results defined by SSPC-SP 6, Commercial Blast Cleaning.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that mounting surfaces are properly prepared.

3.02 PREPARATION

- A. Do not start work until conditions are satisfactory.
- B. Take field measurements prior to preparation of Shop Drawings and fabrication, where possible.

1. Do not delay job progress; allow for trimming and fitting where taking field measurements before fabrication might delay work.
- C. Coordinate and furnish anchorages, setting Plans, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors, which are to be embedded in concrete or masonry construction.
 1. Coordinate delivery of such items to project site.

3.03 FINAL ASSEMBLY

- A. Porcelain Panels: Assemble all porcelain enamel sign components flush, true and accurately straight as indicated on approved Shop Drawings for each type of sign.
- B. Hardware:
 1. Furnish and install all hardware for the attachment of porcelain panels to other sign components.
 2. In addition, furnish any other hardware item not specified which would normally be furnished or required for proper functioning of signs as indicated on the Plans.
- C. Anchor Bolts:
 1. Furnish anchor bolts and other connectors required for securing sign supports to in-place work.
 2. Furnish templates and other devices as necessary for pre-setting bolts and other anchors to accurate locations.

3.04 ROADWAY SIGNS

- A. Install roadway signs in accordance with the Contract Documents, Caltrans Standard Specifications Section 56-2 or as directed by the Engineer. Set height of pole mounted signs and other way finding signs as specified by local agencies having jurisdiction or OCTA for the indicated application.
- B. All signs shall be of high intensity grade (Diamond Grade Reflective) with protective overlay film.
- C. Existing signs and poles as shown on the plans shall be relocated to a new location (Protected) and reinstalled.
- D. All Roadway Signs within the City right-of-way shall comply with the City's permit requirements and the Signing and Striping Plans approved by the City and associated City Supplemental Provisions.

PART 4 - MEASUREMENT AND PAYMENT**4.01 MEASUREMENT**

- A. Roadway Signs will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of values, as applicable, as derived from the Plans will be used as the basis for this measurement.

4.02 PAYMENT

- A. Roadway Signs furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.
- B. This price shall be full compensation for including multiple sign faces, sign post, anchors, hardware, concrete post foundation, galvanizing, and fasteners described by the Contract Documents and as directed by the Engineer.

END OF SECTION

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SECTION 10 14 55

RAILROAD SIGNAGE

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section consists of furnishing all labor, materials and equipment necessary and incidental to maintaining existing railroad signage and constructing new railroad signage at the locations indicated in the reference Specifications, on the contract plans.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 2. Division 01 - General Requirements.
- C. Work Included:
 - 1. All Work associated with constructing new and maintaining existing railroad signage along the right-of-way, including excavation for signposts.
 - 2. If the Contractor cannot construct the signage at the locations indicated in the plans or standards due to obstructions, clearance limitations or topography, request direction from Engineer.

1.02 SUBMITTALS

- A. Submit, under the provisions of Division 1 the following information:
 - 1. Compliance: Manufacturer or Supplier's certifications stating that the Materials delivered to the site are in compliance with these Specifications.
 - 2. Compliance: Submit a certificate of compliance for aluminum sheeting, retroreflective sheeting, screened-process colors, nonreflective, opaque black film, protective-overlay film, and anti-graffiti overlay.
 - 3. Shop Drawings: Details of sign lettering, manufacturer's information for materials, posts, foundations, anchor details (including anchorage) detail.
 - 4. Upon request, submit test samples of sign panels and materials at various stages of production. Sign panel samples shall be at least 12 by 12 inches in size and include background material legend.
 - 5. Within 15 days before starting sign fabrication, submit at least three copies

of quality control plan for sign panels. Allow 10 days for OCTA review. The Contractor shall not start fabricating sign panels until the Engineer accepts the quality control plan.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. The Contractor shall use materials and methods, which comply with the SCRRA Engineering Standards (ES). Railroad signage shall conform to the following Standard Drawings:
1. Sign lettering shall conform to SCRRA ES1212, Arial Bold Lettering or to the SCRRA Engineering Standards drawing for a specific sign.
 2. Derail switch target signage shall conform to SCRRA ES2610, Derailing Switch Target and ES2611, Derail Signs.
 3. Derail switch notice signage shall conform to SCRRA ES2612, Derailing Switch Notice.
 4. Safety lock indication signage shall be at the option of the Contractor, and approved by the Engineer.
 5. Switch stand target colors shall conform to SCRRA ES2703, Color Indications of Targets and Lenses on Switch Stands.
 6. Station train and locomotive position spot signs shall conform to SCRRA ES3330-01 through ES3330-06.
 7. Other station signs shall conform to SCRRA ES3301 through ES3332.
 8. Highway-railroad crossing crossbuck signs for public crossings shall conform to SCRRA ES4310, Highway-Railroad Crossing Crossbuck Signs.
 9. Private, pedestrian and bicycle railroad grade crossing signs shall conform to SCRRA ES4311, Private, Pedestrian and Bicycle Railroad Grade Crossing Signs.
 10. Private crossing closure notification sign shall conform to SCRRA ES4312, Private Crossing Closure Notification Signs.
 11. Sign post, anchors and fasteners shall conform to SCRRA ES5210, Details for Installing Signs at Grade.
 12. Milepost signs shall conform to SCRRA ES5211, Milepost.
 13. Permanent speed restriction signs shall conform to SCRRA ES5213, Permanent Speed Restriction Signs.

14. No trespassing signs shall conform to SCRRA ES5214, Warning Signs.
15. Stop, slow and resume speed flags and signs shall conform to SCRRA ES5215, Stop, Slow and Resume Speed Flags and Signs.
16. Whistling Point/Quiet zone signs shall conform to SCRRA ES5216, Whistling Point/Quiet Zone Sign.
17. Yard limit signs for terminal tracks shall conform to SCRRA ES5217, Yard Limit Sign for Terminal Tracks.
18. Control Point (CP) limit signs and markings shall conform to ES5218, Control Point (CP) Limit Sign and Markings.
19. Flag stanchions shall conform to ES5219, Flag Stanchion.
20. Station signs for other than CTC territory shall conform to SCRRA ES5222, Station Signs for Other Than CTC Territory.
21. Mechanical Limit and No Ride Zone signs shall conform to SCRRA ES5223, Mechanical Limit and No Ride Zone Signs.
22. Warning paddles shall conform to ES5225, Warning Paddle.
23. Warning Signs for Underground Cables shall conform to SCRRA ES5229.
24. Bridge, trestle and culvert number signs shall conform to SCRRA ES6101, Bridge, Trestle and Culvert Numbers.
25. Radio channel sign shall conform to ES6103, Radio Channel Sign.
26. Tunnel exit sign shall conform to SCRRA ES6104, Tunnel Exit Sign.
27. Tunnel numbers shall conform to SCRRA ES6102, Tunnel Numbers.
28. Radio channel signs shall conform to SCRRA ES6103, Begin Channel Sign.
29. ATS sign shall conform to SCRRA ES8260, ATS Sign.
30. Emergency Notification Sign for Highway-Rail Crossing shall conform to SCRRA ES8270, Emergency Notification Sign for Highway-Rail Crossing.
31. Begin CTC/End CTC signs shall conform to SCRRA ES8291, Begin CTC/End CTC Sign.
32. Stop sign shall conform to SCRRA ES8292, Stop Sign.
33. Block signal with "P" Plate signs shall conform to SCRRA ES8545, Block Signal With "P" Plate.
34. Other signs shall be as referenced or as shown on the Contract Plans.

- B. Signs shall be free from blemishes that could affect serviceability and detract from the general sign color and appearance when viewed during the daytime and nighttime from a distance of 25 feet. The face of completed signs shall be uniform, flat, smooth, and free of defects, scratches, wrinkles, gel, hard spots, streaks, extrusion marks, and air bubbles. The front, back, and edges of sign panels shall be free of router chatter marks, burns, sharp edges, loose rivets, delaminated skins, excessive adhesive over-spray, and aluminum marks.
- C. Type Class IX retroreflective sheeting shall have Class 1, 3, or 4 adhesive backing. The adhesive backing shall be pressure sensitive and fungus resistant.
- D. The type of material used for screened-process colors, nonreflective, opaque, black film, and protective overlay film shall be the type recommended by the retroreflective sheeting manufacturer.
- E. Screened-process colors and nonreflective, opaque, black film shall have equivalent outdoor weatherability characteristics as the retroreflective sheeting specified in ASTM D4956.
- F. Cured, screened-process colors shall be able to withstand removal when tested by applying the 3M Company's Scotch brand cellophane tape no. 600 or equivalent tape over the color and removing it with a single, quick motion at a 90 degree angle normal to the surface of the sign's face.
- G. Aluminum sheeting for framed and unframed panels shall be aluminum alloy 6061-T6.

2.02 FABRICATION

- A. Retroreflective Sheeting
 - 1. Retroreflective sheeting shall be applied to sign panels at the fabrication plant under the retroreflective sheeting manufacturer's instructions without appreciable stretching, tearing, and damage.
 - 2. The orientation of the legend shall comply with the retroreflective sheeting manufacturer's instructions.
 - 3. The retroreflective sheeting on a sign panel with a minor dimension of 48 inches or less shall be a single, contiguous sheet without splices except for the splices produced during the manufacturing process of the retroreflective sheeting. A sign panel with a minor dimension greater than 48 inches may have 1 horizontal splice in the retroreflective sheeting other than the splices produced during the manufacturing process of the retroreflective sheeting.
 - 4. Unless the retroreflective sheeting manufacturer's instructions require a different method, splices in the retroreflective sheeting shall overlap by a minimum of one (1) inch. The retroreflective sheeting on either side of a splice shall not exhibit a color difference under incident and reflected light.

B. Storage and Handling

1. Protect, transport, and store sign panels fabricated with screened-process colors under the retroreflective sheeting manufacturer's instructions.
2. Transport sign panels so that the face of the panels are protected from damage and weather. Ship the panels on pallets, in crates, or in tier racks. Ship the panels vertically on edge. Do not stack the panels horizontally. Place padding and protective materials between the panels as necessary. Keep the panels dry during transit.
3. Store sign panels in a dry environment at all times. Store the panels vertically on edge whether indoors or outdoors. Do not store the panels directly on the ground. Do not let the panels get wet during storage. In areas of high heat and humidity, store the panels in enclosed, climate-controlled trailers or containers. Store the panels indoors whenever the storage duration will exceed 30 days.
4. The fabricator shall perform all patterns, layouts, and set-ups necessary for the screening process.

C. Aluminum Sheeting

1. The alloy and temper of aluminum sheeting shall comply with ASTM B209 for the designation specified.
2. Aluminum sheeting shall be pretreated for corrosion resistance under ASTM B449. The surface of the aluminum sheeting shall be cleaned, deoxidized, and coated with a light, tightly adherent chromate conversion coating free of powdery residue. The conversion coating shall be Class 2 with a weight from 10 milligrams per square foot to 35 milligrams per square foot and an average weight of 25 milligrams per square foot. After the cleaning and coating process, protect the aluminum sheeting from exposure to grease, oils, dust, and contaminants.
3. Aluminum sheeting shall be free of buckles, warps, dents, cockles, burrs, and defects resulting from fabrication.

PART 3 - EXECUTION**3.01 MAINTENANCE AND PROTECTION OF EXISTING SIGNAGE**

- A. Maintain and protect in place the existing railroad signage until such time as it can be replaced with new signage, or relocated at a permanent location, as shown on the Contract Drawings. Signs may be temporarily relocated to prevent their damage. Contractor shall confer with the Engineer for proper location and orientation of relocated signs.
- B. No existing signage shall be removed unless approved by the Engineer.
- C. Any existing railroad Milepost, whistling Post/Quiet Zone, Permanent Speed Restriction, Yard Limit, Control Point, Radio Channel, ATS, Block Signal With "P"

Plate, or Derail signs damaged by the Contractor's operations shall be replaced within 36 HRS at the Contractor's sole expense. Any other signage damaged by the Contractor's operations shall be replaced within 8 days, at the Contractor's expense. Signage not replaced or repaired within these time periods will be replaced by the Authority at the Contractor's expense; the cost of such replacement will be deducted from any payment due the Contractor.

- D. Placement of temporarily relocated and permanent signs shall comply with current editions of CPUC General Order 26 and 118.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Railroad Signage will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of values, as applicable, as derived from the Plans will be used as the basis for this measurement.

4.02 PAYMENT

- A. Railroad Signage furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.
- B. This price shall be full compensation for including multiple sign faces, sign post, anchors, hardware, concrete post foundation, galvanizing, and fasteners, removal of existing signs, posts, and foundations, and relocation of existing signs described by the Contract Documents.

END OF SECTION

SECTION 12 67 23
BENCHES AND TRASH CONTAINERS

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section consists of the Contractor furnishing all labor, materials, tools and equipment necessary and incidental to the provision and installation of benches and trash containers as indicated on the Contract Drawings, as specified herein and as directed by the Engineer.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Section 05 12 23 - Structural Steel
 - 2. Section 05 55 00 - Miscellaneous Metal

1.02 REFERENCES

Comply with all local, State and Federal codes, regulations, specifications, standards and recommended practices and in particular:

1.03 SUBMITTALS

Submit the following in accordance with Section 01 33 00, Submittal Procedures.

- A. Data: Submit copies of manufacturer's specifications giving sizes, materials, finishes, installation instructions.
- B. Shop Drawing and Design: Submit copies of manufacturer's bench embedded mounting frame foundation design and details.
- C. Samples: Submit manufacturer's color chips for standard colors. The Engineer will select the color from the colors submitted.
- D. Buy America Certificates

1.04 DELIVERY

Delivery: Do not deliver benches or trash containers until the platform construction is ready for their installation.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Trash Containers: Manufacturer indicated in plans to match existing station trash

containers or equal approved by the Engineer.

- B. Benches: Tolar Manufacturing, or substantially equivalent steel transit bench manufacturer approved in writing by OCTA.

2.02 MATERIALS AND COMPONENTS

- A. Trash Containers shall be blast resistant construction with high strength steel outer shell and compressive inner layer designed to absorb major blast energy with remaining blast energy vented upwards away from public. Trash container will have interior removable plastic trash bag.
- B. Benches:
 - 1. Two-seat transit bench units
 - 2. Steel construction
 - 3. ADA compliant seat back
 - 4. Without vagrant bars
 - 5. Without arm rests
 - 6. Wire grid seat and back
 - 7. Embedded mounting frame foundation (not surface mounted/bolt-down)
 - 8. Color shall match existing station benches and shall be approved in writing by OCTA prior to ordering benches
 - 9. Manufacturer Applied Coating:
 - a. Shot blasted and Cleaned per manufacturers specifications
 - b. Corrosion resistant, zinc rich epoxy undercoat
 - c. Exterior rated Fluoropolymer Resin or TGIC Polyester Powdercoat topcoat with 8 to 10 mil thickness
 - 10. Five (5) year warranty on both coating and materials

PART 3 - EXECUTION

3.01 INSPECTION

Verify conditions and measurements affecting the work of this Section at site. Make sure that detrimental conditions are corrected before proceeding with installation.

3.02 INSTALLATION

- A. Install equipment plumb, level and secure in compliance with their manufacturer's recommendations. Trash containers and benches are to be securely bolted to the concrete where they are installed.
- B. Touch-up minor damage or replace damaged parts. Replace, at no cost to OCTA, materials that are damaged beyond satisfactory field repair.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Benches will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of values, as applicable, as derived from the Plans will be used as the basis for this measurement.
- B. Trash Containers will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of values, as applicable, as derived from the Plans will be used as the basis for this measurement.

4.02 PAYMENT

- A. Benches furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.
- B. Trash Containers furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, coordination of bench installation with platform construction, anchorage to platform and associated fastening components and/or cast in place anchorage system, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.

END OF SECTION

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SECTION 26 05 00

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Basic requirements for electrical systems, including lighting for all platforms, walkways, and landscape areas.
 - 1. Site electrical.
 - 2. Service Pedestals.
 - 3. Building wire and connectors.
 - 4. Outdoor Switchboard with Utility Metering Section/Electricity metering components.
 - 5. Sleeves for electrical penetrations.
 - 6. Cutting and patching for electrical construction.
 - 7. Accessories required for a complete installation.
 - 8. Training requirements.
- B. Requirements of this Section apply to all Sections in Division 26, Electrical.

1.02 REFERENCES

- A. City of Anaheim Department of Public Utilities, Electric Construction Standards
- B. Southern California Regional Rail Authority (SCRRA)
 - 1. SCRRA Signaling and Communications Standards
 - 2. SCRRA Design Criteria Manual
 - 3. SCRRA Engineering Standard Plans
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. NEMA 250, Enclosures for Electrical Equipment (1000 V maximum).

- F. IEEE C2, National Electric Safety Code.
- G. UL 508A, Industrial Control Panels.
- H. ASTM A123, Standard Specification for Zinc (Hot-Dip galvanized) Coating on Iron and Steel products.
- I. ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.03 DEFINITIONS

- A. Product Types:
 - 1. FMC: Flexible metallic conduit.
 - 2. LFMC: Liquid tight flexible metal conduit.
 - 3. RMC: Rigid metallic conduit, specifically rigid galvanized steel.
 - 4. RNC: Rigid nonmetallic conduit, NEMA PC-2.
 - 5. PVC-coated RMC: PVC-coated rigid galvanized steel.
- B. For the purpose of providing material and installing electrical work the following definitions shall be used:
 - 1. Outdoor area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.
 - 2. Architecturally finished interior area; offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.
 - 3. Non-architectural finished interior area: mechanical, electrical, pump rooms and other similar process type rooms.
 - 4. Highly corrosive and corrosive area: areas identified in the drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.
 - 5. Hazardous areas: Class I, II or III areas as defined in NFPA 70 (NEC).

1.04 SUBMITTALS

- A. Shop Drawing Transmittal:
 - 1. General Requirements:
 - a. Provide manufacturer's technical information on products and product model descriptive bulletin.

- b. Include data sheets with manufacturer's name and product model number, clearly identify all optional accessories using a box or highlight around the option. Clearly indicate options that will not be used in the Project using a "slash" or "X".
- c. Acknowledgement that products are UL listed or are constructed utilizing UL recognized components.
- d. Manufacturer's delivery, storage, handling and installation instructions.
- e. Product installation details.
- f. See individual specification sections for additional requirements.
- g. Dimensioned plans and sections or elevation layouts and single line diagram of electricity metering component assemblies.

1.05 COORDINATION

- A. Provide functioning electrical systems in compliance with National Electrical Code (NEC), manufacturer's instructions, performance requirements in Contract Documents, and modifications resulting from reviewed shop drawings and field coordinated Drawings.
- B. Provide complete power and control raceway and wiring for all mechanical equipment electrical loads.
- C. Provide 208Y/120 V three phase and 120/240 V single phase electrical distribution system including raceways and boxes, wires, grounding and bonding, wiring devices as necessary for a complete, operative, functional electric system.
- D. Coordinate chases, slots, inserts, sleeves, and openings for electrical supports, raceways, and cable with general construction work.
- E. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.
 - 1. Coordinate installation of large equipment that requires positioning before closing in the building.
- F. Coordinate electrical service connections to components furnished by utility companies.
- G. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for service entrances and electricity metering components.
- H. Coordinate location of access panels and doors for electrical items concealed by finished surfaces.

- I. Where electrical identification devices are applied to field finished surfaces, coordinate installation of identification devices with completion of finished surface.
- J. Coordinate underground conduit installation with other trades.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Provide all components of a similar type by one (1) manufacturer.

2.02 MATERIALS

- A. Electrical Equipment Support Pedestals and /or Racks:
 - 1. Approved Manufacturers:
 - a. Modular Strut:
 - 1) Unistrut Building Systems.
 - 2) B-Line.
 - 3) Globe Strut.
 - 2. Material requirements:
 - a. Modular strut:
 - 1) Galvanized steel: ASTM A123 or ASTM 153.
 - 2) Stainless Steel: AISI Type 316.
 - b. Mounting hardware:
 - 1) Galvanized steel.
 - 2) Stainless steel.
 - c. Anchorage as per Division 5.

2.03 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeve: ASTM A53 Type E, Grade B, Schedule 40, galvanized steel, plain ends.

PART 3 - EXECUTION**3.01 ELECTRICAL EQUIPMENT INSTALLATION**

- A. Install and wire all equipment, including pre-purchased equipment, and perform all tests necessary to assure conformance to the Plans and Specification Sections and ensure that equipment is ready for operation and safe for energization.
- B. Comply with NECA 1.
- C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom and meet the minimum code requirements.
- E. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- F. Equipment: Install to facilitate service, maintenance, and repair or replacement of components.
 - 1. Connect for ease of disconnecting, with minimum interference with other installations.
- G. Right of Way: Give to raceways and piping systems installed at a required slope.

3.02 APPLICATIONS

- A. Raceways:
 - 1. Outdoor Installations:
 - a. Exposed: RMC.
 - b. Concealed: RMC.
 - c. Underground, Single Run: Concrete encased RNC with reinforcement as indicated on Plans.
 - d. Underground, Grouped: Concrete encased RNC with reinforcement as indicated on Plans.
 - e. Connection to Vibrating Equipment: LFMC.
 - f. Boxes and Enclosures: NEMA 250, Type 3R or Type 4, unless otherwise indicated.

3.03 RACEWAY AND CABLE INSTALLATION

- A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.
- B. Keep legs of raceway bends in the same plane and keep straight legs of offsets parallel.
- C. Use RMC elbows where RNC turns out of slab.
- D. Use PVC-coated RMC for transition from underground to aboveground.
- E. Install pull wires in empty raceways.
 - 1. Use oven polypropylene or monofilament plastic line with not less than 200 LB tensile strength.
 - 2. Leave at least 12 IN of slack at each end of pull wires.
- F. Install interior telephone and signal system raceways, 2 IN trade size and smaller, in maximum lengths of 150 FT and with a maximum of two 90 degree bends or equivalent.
 - 1. Add pull boxes where necessary to accomplish this.
- G. Set floor boxes level and trim after installation to fit flush to finished floor surface.

3.04 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL CIRCUITS

- A. Use wiring methods specified below to the extent permitted by applicable codes as interpreted by authorities having jurisdiction.
- B. Exposed Feeders: Insulated single conductors in raceway.
- C. Concealed Feeders in Ceilings, Walls, Gypsum Board Partitions: Insulated single conductors in raceway.
- D. Concealed Feeders in Concrete, Below Floors on Grade: Insulated single conductors in raceway.
- E. Exposed Branch Circuits: Insulated single conductors in raceway.
- F. Concealed Branch Circuits in Ceilings, Walls and Gypsum Board Partitions: Insulated single conductors in raceway.
- G. Concealed Branch Circuits in Concrete, below Floors on Grade: Insulated single conductors in raceway.
- H. Underground Feeders and Branch Circuits: Insulated single conductors in raceway.

- I. Remote Control Signaling and Power-Limited Circuits, Classes 1, 2, and 3: Insulated conductors in raceway unless otherwise indicated.

3.05 WIRING INSTALLATION

- A. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

3.06 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves where electrical raceways, cables, wireways, cable trays, or busways penetrate concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 IN above finished floor level.
- F. Size pipe sleeves to provide 1/4 IN annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete or masonry.
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain.
 - a. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Where sleeves are indicated, seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations.
 - 1. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.
- J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.07 FIRESTOPPING

- A. Apply firestopping to cable and raceway sleeves and other penetrations of fire rated floor and wall assemblies to restore original undisturbed fire resistance ratings of assemblies.

3.08 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations.
 - 1. Perform cutting by skilled mechanics of trades involved.
- B. Repair, refinish, and touch up disturbed finish materials and other surfaces to match adjacent undisturbed surfaces.

3.09 TRAINING PROGRAM

- A. General Requirements:
 - 1. The Contractor is responsible for training as outlined in this Section.
 - a. Maintenance management classes shall take place prior to the occupancy of the facility, as required and approved by OCTA.
 - b. Mechanics training will commence only after installation of equipment is complete at the facility.
 - c. Training shall be conducted at location determined by OCTA.
 - d. Hours for training shall be between 7:00 a.m. and 7:00 p.m. unless specifically permitted otherwise.
- B. The Contractor is responsible for ensuring that training instructors are not only familiar with technical information, but also able to utilize proper methods of instruction, training aids, audiovisuals, etc., to ensure effective presentations.
- C. The Contractor is responsible for providing all training aids, audiovisual equipment, and visual aids for the conduct of these courses.
- D. Training materials are to become the property of OCTA at the conclusion of training.
- E. Submission and Approval of Training Plans:
 - 1. The Contractor shall meet with OCTA's quality assurance manager not later than three weeks prior to the start of formal training.
 - a. At that time, Contractor will submit lesson plans and an outline of the training program and will demonstrate any training aids involved.

- b. Handouts are also to be presented for approval and provided later in a ratio of one per student.
 - c. Each location shall receive a complete set of prints and schematics.
 - 2. The Contractor will submit in writing his plans for meeting the Specification training requirements.
 - a. OCTA's quality assurance manager will approve and then coordinate and schedule all training involved.
- F. The Contractor will outline specific objectives for each of the courses that he is required to present.
 - 1. The course should include sessions in safety and machine operation, as well as a comprehensive seminar teaching basic skills and knowledge of each operation.
 - a. The course should include both classroom and practical exercise sessions and shall provide the mechanic with the basic knowledge necessary to utilize all training materials.
 - b. The Contractor will provide a detailed schedule outlining the length and content of each of these sessions in accordance with the guidelines established.
 - 2. The training program shall include familiarization with equipment operation and performance and detailed instruction in operation, maintenance, and test procedures.
 - a. Training duration shall be as specified in Specification Sections.
- G. Training related to electrical systems shall include, but not be limited to, the following:
 - 1. A written test, as well as a hands-on demonstration of competence by the student.
 - 2. Troubleshooting instruction.
 - 3. Troubleshooting guides and protocols.
 - 4. Maintainability demonstration for each system.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Basic Electrical Materials and Methods will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of values, as applicable, as derived from the Plans will be used as the basis for this measurement.
- B. All material, work and services included in Sections 26 05 50, Overcurrent Protection Devices; 26 06 00, Grounding and Bonding; 26 7 10, Seismic Controls for Electric Works; 26 07 50, Electrical Identification; 26 08 00, Electrical Testing; 26 14 00, Wiring Devices; 26 28 00, Overcurrent and Short Circuit Protective Devices; 26 28 16, Safety Switches; 26 28 90, Transient Voltage Suppression; 26 41 00, Enclosed Switches and Circuit Breakers; 26 42 00, Enclosed Controllers; 26 44 10, Switchboards; 26 44 20, Service Pedestals and Panelboards; 26 46 00; and Dry Type Transformers (600 V and Less) will be included in this Section and are considered incidental to work under this Section and will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer.

4.02 PAYMENT

- A. Basic Electrical Materials and Methods furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications.

END OF SECTION

SECTION 26 05 43

ELECTRICAL: EXTERIOR UNDERGROUND

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Material and installation requirements for:
 - a. Handholes.
 - b. Underground conduits and ductbanks.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 01 - General Requirements.
 - 2. Division 03 - Concrete.
 - 3. Section 26 07 50 - Electrical Identification.
 - 4. Section 26 06 00 - Grounding and Bonding.
 - 5. Section 26 13 00 – Conduits, Raceways and Boxes.
 - 6. Section 33 05 23 – Steel Casing.

1.02 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. HB, Standard Specifications for Highway Bridges.
 - 2. ASTM International (ASTM):
 - a. A536, Standard Specification for Ductile Iron Castings.
 - 3. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 4. Society of Cable Telecommunications Engineers (SCTE):

- a. 77, Specification for Underground Enclosure Integrity.

1.03 DEFINITIONS

- A. Direct-buried conduit(s):
 - 1. Individual (single) underground conduit.
 - 2. Multiple underground conduits, arranged in one or more planes, in a common trench.
- B. Concrete encased ductbank: An individual (single) or multiple conduit(s), arranged in one or more planes, encased in a common concrete envelope.

1.04 SUBMITTALS

- A. Shop Drawings:
 - 1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
 - 2. Product technical data:
 - a. Provide submittal data for all products specified in PART 2 of this Specification Section.
 - 3. Fabrication and/or layout drawings:
 - a. Provide dimensional drawings of each handhole indicating all specified accessories and conduit entry locations.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Prefabricated composite handholes:
 - a. Quazite Composolite.
 - b. Armorcast Products Company.
 - c. Synertech.
 - 2. Handhole and ductbank accessories:
 - a. Neenah.

- b. Unistrut.
 - c. Condux International, Inc.
 - d. Underground Devices, Inc.
- B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.02 HANDHOLES

- A. Prefabricated Composite Material Handholes:
 - 1. Handhole body and cover: Fiberglass reinforced polymer concrete conforming to all test provisions of SCTE 77.
 - 2. Minimum load ratings: SCTE 77 Tier 8 and as Specified on Contract Drawing E1.
 - 3. Open bottom.
 - 4. Stackable design as required for specified depth.
 - 5. Cover:
 - a. Engraved legend of "ELECTRIC" or "COMMUNICATIONS".
 - b. Non-gasketed bolt down with stainless steel penta head bolts.
 - c. Lay-in non-bolt down, when cover is over 100 lbs.
 - d. One or multiple sections so the maximum weight of a section is 125 lbs.
 - 6. Cover lifting hook: 24 in. minimum in length.
- B. Precast Handholes:
 - 1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures:
 - 2. AASHTO live load rating: H-20 for full deliberate vehicle traffic.
 - 3. Mating edges: Tongue and groove type.
 - 4. Cover extension rings as required.
 - 5. Cable pulling eyes opposite all conduit entrances.
 - a. Coordinate exact location with installation contractor.

2.03 UNDERGROUND CONDUIT AND ACCESSORIES

- A. Concrete: Comply with Division 03 Specifications.
- B. Conduit: See Specification Section 26 13 00.
- C. Duct Spacers/Supports:
 - 1. High density polyethylene or high impact polystyrene.
 - 2. Interlocking.
 - 3. Provide 2 in. minimum spacing between conduits.
 - 4. Accessories, as required:
 - a. Hold down bars.
 - b. Ductbank strapping.

PART 3 - EXECUTION**3.01 GENERAL**

- A. Drawings indicate the intended location of handholes and routing of ductbanks and direct buried conduit.
 - 1. Field conditions may affect actual routing.
- B. Handhole Locations:
 - 1. Approximately where shown on the Drawings.
 - 2. As required for pulling distances.
 - 3. As required to keep pulling tensions under allowable cable tensions.
 - 4. As required for number of bends in ductbank routing.
 - 5. Shall not be installed in a swale or ditch.
 - 6. Determine the exact locations after careful consideration has been given to the location of other utilities, grading, and paving.
 - 7. Locations are to be approved by the Engineer prior to excavation and placement or construction of handholes.
- C. Install products in accordance with manufacturer's instructions.

- D. Install handholes in conduit runs where indicated or as required to facilitate pulling of wires or making connections.
- E. Comply with Specification Section 33 05 24 for trenching, backfilling and compacting.

3.02 HANDHOLES

- A. Prefabricated Composite Material Handholes:
 - 1. For use in areas subjected to occasional non-deliberate vehicular traffic.
 - 2. Place handhole on a foundation of compacted 1/4 to 1/2 in. crushed rock or gravel a minimum of 8 IN thick and 6 IN larger than handholes footprint on all sides.
 - 3. Provide concrete encasement ring around handhole per manufacturers installation instructions (minimum of 10 in. wide x 12 in deep).
 - 4. Install so that the surrounding grade is 1 in. lower than the top of the handhole.
 - 5. Size: As indicated on the Drawings or as required for the number and size of conduits.
 - 6. Provide cable rails and pulling eyes as needed.
- B. Precast Handholes:
 - 1. For use in vehicular and non-vehicular traffic areas.
 - 2. Construction:
 - a. Grout or seal all joints, per manufacturer's instructions.
 - b. In each handhole, drive copper clad ground rod into the earth with approximately 6 in. exposed above finished floor.
 - 1) Drill opening in floor for ground rod.
 - 2) Connect all metallic components to ground rod as shown in the Contract Drawings.
 - 3) Utilize a ground bar in the handhole if the quantity of ground wires exceeds three (3).
 - a) Connect ground bar to ground rod with a #2/0 AWG minimum copper wire.

3. Place handhole on a foundation of compacted 1/4 to 1/2 in. crushed rock or gravel a minimum of 8 IN thick and 6 in. larger than handholes footprint on all sides.
4. Install so that the top of cover is 1 in. above finished grade.
 - a. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of handhole frame to temporarily elevate handhole cover to existing grade level.
5. After installation is complete, backfill and compact soil around handholes.
6. Handhole size:
 - a. As indicated on the Drawings or as required for the number and size of conduits entering or as indicated on the Drawings.

3.03 UNDERGROUND CONDUITS

A. General Installation Requirements:

1. Ductbank types per location:
 - a. Reinforced concrete ductbank:
 - 1) As indicated in the Ductbank Schedule.
 - b. Concrete encased ductbank:
 - 1) Under roads.
 - 2) Conduits containing medium voltage cables.
 - 3) Pad mounted transformer secondaries.
 - 4) Plant process equipment feeders and controls.
 - 5) As indicated in the Ductbank Schedule.
 - c. Direct-buried conduit(s):
 - 1) Area/Roadway lighting.
 - 2) As indicated in the Ductbank Schedule.
 - d. Duct Bank in Steel Casing:
 - 1) Under railroad track (see Contract Drawings)

2. Do not place concrete or soil until conduits have been observed by the Engineer.
3. Ductbanks shall be sloped a minimum of 4 in. per 100 ft. or as detailed on the Drawings.
 - a. Low points shall be at handholes.
4. During construction and after conduit installation is complete, plug the ends of all conduits.
5. Provide conduit supports and spacers.
 - a. Place supports and spacers for rigid nonmetallic conduit on maximum centers as indicated for the following trade sizes:
 - 1) 1 in. and less: 3 ft..
 - 2) 1-1/4 to 3 in.: 5 ft.
 - 3) 3-1/2 to 6 in.: 7 ft.
 - b. Place supports and spacers for rigid steel conduit on maximum centers as indicated for the following trade sizes:
 - 1) 1 in. and less: 10 ft.
 - 2) 1-1/4 to 2-1/2 in.: 14 ft.
 - 3) 3 in. and larger: 20 ft.
 - c. Securely anchor conduits to supports and spacers to prevent movement during placement of concrete or soil.
6. Stagger conduit joints at intervals of 6 IN vertically.
7. Make conduit joints watertight and in accordance with manufacturer's recommendations.
8. Accomplish changes in direction of runs exceeding a total of 15 degrees by long sweep bends having a minimum radius of 25 ft.
 - a. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
9. Furnish manufactured bends at end of runs.
 - a. Minimum radius of 18 in. for conduits less than 3 in. trade size and 36 in. for conduits 3 in. trade size and larger.
10. Field cuts requiring tapers shall be made with the proper tools and shall match factory tapers.

11. After the conduit run has been completed:
 - a. Prove joint integrity and test for out-of-round duct by pulling a test mandrel through each conduit.
 - 1) Test mandrel:
 - a) Length: Not less than 12 in.
 - b) Diameter: Approximately 1/4 in. less than the inside diameter of the conduit.
 - b. Clean the conduit by pulling a heavy duty wire brush mandrel followed by a rubber duct swab through each conduit.
 12. Pneumatic rodding may be used to draw in lead wire.
 - a. Install a heavy nylon cord free of kinks and splices in all unused new ducts.
 - b. Extend cord 3 ft. beyond ends of conduit.
 13. Transition from rigid non-metallic conduit to rigid metallic conduit, per Specification Section 26 13 00, prior to entering a structure or going above ground.
 - a. Except rigid non-metallic conduit may be extended directly to handholes, pad mounted transformer boxes and other exterior pad mounted electrical equipment where the conduit is concealed within the enclosure.
 - b. Terminate rigid PVC conduits with end bells.
 - c. Terminate steel conduits with insulated bushings.
 14. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-buried wire and cable in accordance with Specification Section 26 07 50.
 15. Placement of conduits stubbing into handholes shall be located to allow for proper bending radiuses of the cables.
- B. Concrete Encased Ductbank:
1. Ductbank system consists of conduits completely encased in minimum 2 in. of concrete and with separations between different cabling types as detailed on the Drawings.
 2. Install so that top of concrete encased duct, at any point:
 - a. Is not less than 24 in. below grade.

- b. Is below pavement sub-grading.
 - 3. Where identified and for a distance 10 ft. either side of the area, the concrete shall be reinforced.
 - a. The reinforcement shall consist of #4 bars and #4 ties placed 12 IN on center, in accordance with Division 3 Specification Sections or as detailed on the Drawings.
 - 4. Conduit supports shall provide a uniform minimum clearance of 2 IN between the bottom of the trench and the bottom row of conduit.
 - 5. Conduit separators shall provide a uniform minimum clearance of 2 IN between conduits or as required in Specification Section 26 13 00 for different cabling types.
- C. Direct-Buried Conduit(s):
- 1. Install so that the top of the uppermost conduit, at any point:
 - a. Is not less than 36 in. below grade.
 - b. Is below pavement sub-grading.
 - 2. Provide a uniform minimum clearance of 2 in. between conduits.
 - a. Maintain the separation of multiple planes of conduits by one of the following methods:
 - 1) Install multilevel conduits with the use of conduit supports and separators to maintain the required separations, and backfill with flowable fill (100 psi) or concrete per Specification Section 03 31 00.
 - 2) Install the multilevel conduits one level at a time.
 - a) Each level is backfilled with the appropriate amount of soil and compaction, per Specification Section 31 20 00, to maintain the required separations.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Measurement for Handholes will be included as an incidental to the work associated with Items in Section 26 13 00, Conduits, Raceways and Boxes and no separate measurement will be made to the Contractor for Work under this Section.

- B. Measurement for Underground Conduits and Ductbanks will be included as an incidental to the work associated with Items in Section 26 13 00, Conduits, Raceways and Boxes and no separate measurement will be made to the Contractor for Work under this Section.

4.02 PAYMENT

- A. Payment for Handholes will be included as an incidental to the work associated with Items in Section 26 13 00, Conduits, Raceways and Boxes and shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.
- B. Payment for Underground Conduits and Ductbanks will be included as an incidental to the work associated with Items in Section 26 13 00, Conduits, Raceways and Boxes and shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.

END OF SECTION

SECTION 26 05 50

OVERCURRENT PROTECTIVE DEVICE COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Computer-based, fault-current, overcurrent protective device coordination studies, the setting of these devices and arc flash hazard report.
 - a. Series-rated devices are prohibited.
 - b. Fused circuit breakers are prohibited.
- B. The Contractor shall furnish Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E- Standard for Electrical Safety in the Workplace.
- C. The Contractor shall furnish and install Arc Flash Hazard labels to all electrical switchboards, panels and subpanels.

1.2 REFERENCES

- A. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
- B. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.
- C. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
- D. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
- E. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations.
- F. American National Standards Institute (ANSI).
- G. The National Fire Protection Association (NFPA):
 - 1. 70, National Electrical Code, latest edition.
 - 2. 70E, Standard for Electrical Safety in the Workplace.

PART 2 - PRODUCTS (NOT USED)**PART 3 - EXECUTION****3.1 ARC FLASH HAZARD ANALYSIS**

- A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.
- B. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 Cal/cm².
- C. Miscoordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the location.
- D. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized

3.2 ARC FLASH WARNING LABELS

- A. The Contractor of the Arc Flash Hazard Analysis shall provide a 3.5 x 5 IN thermal transfer type label of high adhesion polyester for each work location analyzed.
- B. All labels will be based on recommended overcurrent device setting. The label shall include the following information, at a minimum:
 - 1. Location designation.
 - 2. Nominal voltage.
 - 3. Flash protection boundary.
 - 4. Hazard risk category.
 - 5. Incident energy.
 - 6. Working distance.
- C. Labels shall be machine printed, with no field markings.
- D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - 1. For each 480 and applicable 208 V panelboard, one arc flash label shall be provided.
 - 2. For each low voltage switchboard, one arc flash label shall be provided.
 - 3. For each switchgear, one flash label shall be provided.

PART 4 - MEASUREMENT AND PAYMENT**4.1 MEASUREMENT**

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.

END OF SECTION

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SECTION 26 06 00
GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Grounding and bonding of stray current protection for structural steel, bar reinforcing steel, railings, and fencing as identified in the Contract Drawings.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
- C. National Fire Protection Association (NFPA):
 - 1. 70, National Electrical Code (NEC).
 - a. Article 230, Services.
 - b. Article 250, Grounding and Bonding.
 - c. Article 408, Switchboard and Panelboards.
 - d. Article 409, Industrial Control Panels.
 - e. Article 610, Cranes and Hoists.
 - f. Article 620, Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467, Grounding and Bonding Equipment.

1.03 QUALITY ASSURANCE

- A. Assure ground continuity is continuous throughout the entire Project.

B. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled under UL 467 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

1.04 SUBMITTALS

- A. Product Data: Technical data for ground rods and grounding conductors.
- B. Reports: Field quality control test reports.

PART 2 - PRODUCTS**2.01 GENERAL**

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with:

Section 01 33 00 - Submittal Procedures

Section 01 25 00 - Substitution Procedures

Section 01 60 00 - Product Requirements

2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 1. Ground rods and bars and grounding clamps, connectors and terminals:
 - a. Erico Products Inc., Cadweld.
 - b. Burndy.
 - c. Harger Lightning Protection.

- d. Heary Brothers.
 - e. Joslyn.
 - f. Robbins Lightning Protection.
 - g. Thomas & Betts (Blackburn).
 - h. Thompson.
- 2. Exothermic weld connections:
 - a. Erico Products Inc., Cadweld.
 - b. Harger Lightning Protection.
 - c. Thermoweld.
 - 3. Prefabricated composite test stations:
 - a. Quazite Composolite.
 - b. Armorcast Products Company.

2.03 COMPONENTS

- A. Wire and Cable:
 - 1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
 - 2. Insulated conductors: Color coded green, per Specification Section 26 12 00.
 - 3. For insulated conductors, comply with Section 26 12 00 - Conductors and Cables – Low Voltage.
 - 4. Equipment Grounding Conductors: Insulated with green colored insulation.
 - 5. Grounding Electrode Conductors: Stranded cable.
 - 6. Underground Conductors: Bare, stranded, unless otherwise indicated.
 - 7. Copper Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
 - 8. Copper Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 IN wide and 1/16 IN thick.

9. Tinned Copper Bonding Jumper: Tinned copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 IN wide and 1/16 IN thick.
 10. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulated spacer.
 11. Connectors: Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items. Use compression type where exposed and exothermic-welded type, in kit form, selected per manufacturer's written instructions where concealed or buried in earth.
- B. Conduit: As specified in Specification Section 26 13 00.
- C. Ground Bars:
1. Solid copper:
 - a. 5/8 IN thick.
 - b. 2 or 4 IN wide.
 - c. 24 IN long minimum in main service entrance electrical rooms, 12 IN long elsewhere.
 2. Predrilled grounding lug mounting holes.
 3. Stainless steel or galvanized steel mounting brackets.
 4. Insulated standoffs.
- D. Ground Rods:
1. Provide grounding electrodes as many as necessary to maintain maximum resistance as indicated in Section 3.02-4.
 2. 3/4 IN x 10 FT.
 3. Copperclad: Copper clad steel.
 - a. Heavy uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
 - b. Corrosion resistant bond between the copper and steel.
 - c. Hard drawn for a scar-resistant surface.

E. Grounding Clamps, Connectors and Terminals:

1. Mechanical type:
 - a. Standards: UL 467.
 - b. High copper alloy content.
2. Compression type for interior locations:
 - a. Standards: UL 467.
 - b. High copper alloy content.
 - c. Non-reversible.
 - d. Terminals for connection to bus bars shall have two bolt holes.
3. Compression type suitable for direct burial in earth or concrete:
 - a. Standards: UL 467, IEEE 837.
 - b. High copper alloy content.
 - c. Non-reversible.

F. Exothermic Weld Connections:

1. Copper oxide reduction by aluminum process.
2. Molds properly sized for each application.

PART 3 - EXECUTION**3.01 INSTALLATION****A. General:**

1. Install products in accordance with manufacturer's instructions.
2. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250, except where larger sizes are indicated on the Drawings.
3. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections.
4. Where ground conductors pass through floor slabs or building walls provide non-metallic sleeves and install per Specification Section 01 73 20.

5. Do not splice grounding conductors except at ground rods.
 6. Install ground rods and grounding conductors in undisturbed, firm soil.
 - a. Provide excavation required for installation of ground rods and ground conductors.
 - b. Use driving studs or other suitable means to prevent damage to threaded ends of sectional rods.
 - c. Unless otherwise specified, connect conductors to ground rods with compressor type connectors or exothermic weld.
 - d. Provide sufficient slack in grounding conductor to prevent conductor breakage during backfill or due to ground movement.
 - e. Backfill excavation completely, thoroughly tamping to provide good contact between backfill materials and ground rods and conductors.
 7. Do not use exothermic welding if it will damage the structure the grounding conductor is being welded to.
- B. Use copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- C. In raceways, use insulated equipment grounding conductors.
- D. Exothermic Welded Connections: Use for connections to structural steel and for underground connections.
- E. Grounding Bus: Install 24 IN long ground bus in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
1. Use insulated spacer; space 1 IN from wall and support from wall 18 IN above finished floor.
- F. Underground Grounding Conductors: Use copper conductor, No. 4/0 AWG minimum. Bury at least 24 IN below grade or bury directly below duct bank when installed as part of the duct bank.
- G. Equipment Grounding Conductors: Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
1. Install insulated equipment grounding conductors in all feeders and branch circuits.

2. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
 3. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 4. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing an insulated equipment grounding conductor with supply branch-circuit conductors.
- H. Metal Frame Grounding for Buildings: Drive a ground rod at the base of every corner column and at each intermediate exterior column. Connect rod to column with an underground grounding conductor. Interconnect ground rods with a continuous underground conductor (counterpoise), extending around the perimeter of the building, 24 IN minimum from building foundation. Use tinned copper conductor not less than No. 4/0 AWG for underground conductor, and bury 18 IN below grade, minimum.
- I. Ground Rods: Drive ground rods until tops are 12 IN below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
- J. Grounding Conductors: Route along shortest and straightest paths possible. Avoid obstructing access or placing conductors where subjected to strain, impact, or damage.
- K. Bonding Straps and Jumpers: Install so that vibration by equipment mounted on vibration isolation hangers or supports is not transmitted to rigidly mounted equipment. Use exothermic welded connectors for outdoor locations, unless disconnect type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
- L. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

- M. Connections: Make connections so that galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so that metals in direct contact will be galvanically compatible.
1. Use electroplated or hot tin coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum to steel connections with stainless steel separators and mechanical clamps.
 4. Make aluminum to galvanized steel connections with tin plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 6. Exothermic Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 7. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure type connectors.
 8. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
 9. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
 10. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
 11. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

- N. Duct Banks: Install a No. 4/0 grounding conductor below each duct bank in direct contact with the earth.
- O. Handholes: Install a driven ground rod close to wall and set rod depth so that 4 IN will extend above finished floor. If necessary, install ground rod before handhole is placed. Provide a No. 2 bare, copper conductor from ground rod as shown on the Contract Drawings.
- P. Pad Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad mounted equipment and noncurrent carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use copper conductor not less than No. 4/0 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 IN below grade and 6 IN from the foundation.

3.02 FIELD QUALITY CONTROL

- A. Leave grounding system uncovered until observed by Engineer.
- B. Testing: The Contractor shall engage independent agency to perform field quality control testing:
 - 1. After installing grounding system
 - 2. Nominal maximum values are as follows:
 - a. Equipment Rated 500 kVA and Less: 10 ohms.
 - b. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - c. Equipment Rated More Than 1000 kVA: 3 ohms.
 - d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
 - e. Handhole Grounds, Railing, and Stray Current Grounds: 10 ohms.

PART 4 - MEASUREMENT AND PAYMENT

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer

END OF SECTION

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SECTION 26 07 10

SEISMIC CONTROLS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Seismic restraints and earthquake damage reduction measures for electrical components.
 - 2. Accessories required for a complete installation.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A36, Standard Specification for Carbon Structural Steel.
 - 2. A307, Standard Specification Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 - 3. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
- B. State of California Earthquake Regulations:
 - 1. Title 24, California Code of Regulations, Part 2, California Building Code.

1.03 DEFINITIONS

- A. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.
- B. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independently of other structural elements during an earthquake.

1.04 SUBMITTALS

- A. Product Data: Technical data illustrating and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic-restraint component used. Include documentation of evaluation and approval of components by agencies acceptable to authorities having jurisdiction.

- B. Shop Drawings: For components, physical arrangements, and installation details not defined by Drawings. Indicate materials and show calculations, design analysis, details, and layouts, signed and sealed by a Professional Engineer.
- C. Field quality control test reports.

1.05 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in California Building Code unless requirements in this Section are more stringent.
- B. Comply with MFMA-4 of the Metal Framing Manufacturers Association unless requirements of CBC or this Section are more stringent.
- C. Testing Agency Qualifications: An independent testing and inspection agency, acceptable to Authorities Having Jurisdiction, with the experience and capability to conduct the inspection indicated.

1.06 PROJECT CONDITIONS

- A. Project Seismic Zone and Zone Factor as Defined in CBC: 4.
- B. Occupancy Category as Defined in CBC: Refer to Drawings.
- C. Acceleration Factor as Defined in CBC: Refer to Drawings.

1.07 COORDINATION

- A. Coordinate layout and installation of seismic bracing with building structure, architectural features, and mechanical, fire-protection, electrical, and other building systems.
- B. Coordinate concrete bases with building structural system.
- C. Coordination of Bracing Systems:
 - 1. Transverse and longitudinal bracing for seismic forces on suspended electrical systems including conduit, cable tray, bus duct, and equipment.
 - 2. Anchorage of floor and roof mounted electrical equipment.
- D. Seismic Design Requirements:
 - 1. Seismic design criteria: Provide bracing and anchoring for equipment, conduit, cable tray, bus duct, designed, constructed, and installed to resist stresses produced by lateral forces.
- E. Design and install seismic anchorage and bracing for all floor or roof mounted equipment weighing 400 lbs. or more and all suspended or wall mounted equipment weighing 20 lbs. or more.

- F. The following components are exempt from the requirements of this Section:
1. Electrical components in structures assigned to Seismic Design Category C provided that the importance factor (I_p) is equal to 1.0.
 2. Electrical components in Seismic Design Categories D, E, and F where $I_p = 1.0$ and flexible connections between the components and associated ductwork, piping, and conduit are provided and that are mounted at 4 ft. (1.22 m) or less above a floor level and weigh 400 lbs. (1780 N) or less.
 3. Electrical components in Seismic Design Categories D, E, and F weighing 20 lbs. (95 N) or less where $I_p = 1.0$ and flexible connections between the components and conduit are provided, or for distribution systems, weighing 5 lbs./ft. (7 N/m) or less.
- G. Seismic forces shall be presumed to act through the center of mass of the equipment in a direction that will produce the largest single anchor force.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00 - Product Requirements.

2.02 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:
1. Amber/Booth, a VMC Group company.
 2. Cooper B-Line Systems, div. Cooper Industries.
 3. Erico, Inc.
 4. GS Metals Corp.
 5. Loos & Co., Inc.
 6. Mason Industries, Inc.
 7. Powerstrut brand, Power Engineering Co., Inc.
 8. Thomas & Betts Corp.
 9. Unistrut, div. Tyco Electrical and Metal Products.

B. Restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.03 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

- A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Strength in tension and shear of components shall be at least twice the maximum seismic forces for which they are required to be designed.
- B. Concrete and Masonry Anchor Bolts and Studs: Steel expansion wedge type.
- C. Concrete Inserts: Steel channel type.
- D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A325.
- E. Welding Lugs: Comply with MSS SP-69, Type 57.
- F. Beam Clamps for Steel Beams and Joists: Double sided. Single sided type is not acceptable.
- G. Bushings for Floor Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.
- H. Bushing Assemblies for Wall Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.04 SEISMIC BRACING COMPONENTS

- A. Slotted Steel Channel: 1-5/8 in. by 1-5/8 in. cross section, formed from 0.1046 in. thick steel, with 9/16 in. by 7/8 in. slots at a maximum of 2 in. OC in webs, and flange edges turned toward web.
1. Materials for Channel: ASTM A1011.
 2. Materials for Fittings and Accessories: ASTM A575, ASTM A576, or ASTM A36.
 3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.

4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.
- B. Channel Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.
- C. Hanger Rod Stiffeners: Slotted steel channels, installed vertically, with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install seismic restraints according to applicable codes and regulations and as approved by Authorities Having Jurisdiction, unless more stringent requirements are indicated.
- B. Install structural attachments as follows:
 1. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.
 2. Attachments to New Concrete: Bolt to channel type concrete inserts or use expansion anchors.
 3. Attachments to Existing Concrete: Use expansion anchors.
 4. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.
 5. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.
 6. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.
 7. Attachments to Wood Structural Members: Install bolts through members.
 8. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.
- C. Install electrical equipment anchorage as follows:
 1. Anchor panelboards, motor-control centers, motor controls, switchboards, switchgear, transformers, unit substations, fused power circuit devices, transfer switches, busway, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:

- a. Anchor equipment rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.
 - b. Size concrete bases so that expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
 - c. Concrete Bases for Floor Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
 - d. Bushings for Floor Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
 - e. Anchor Bolt Bushing Assemblies for Wall Mounted Equipment: Install to allow for resilient media where equipment or equipment mounting channels are attached to wall.
 - f. Torque bolts and nuts on studs to values recommended by equipment manufacturer.
- D. Install Seismic Bracing:
- 1. Install bracing according to spacings and strengths indicated by approved analysis.
 - 2. Expansion and Contraction: Install to allow for thermal movement of braced components.
 - 3. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.
- E. Accommodation of Differential Seismic Motion: Make flexible connections in raceways, cables, wireway, cable trays, and busway where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

3.02 FIELD QUALITY CONTROL

- A. Testing Agency: OCTA will engage a qualified testing and inspection agency to inspect seismic-control installation for compliance with indicated requirements.
- B. Re-inspection: Correct deficiencies and verify by re-inspection that work complies with requirements.
- C. Provide written report of tests and inspections.

PART 4 - MEASUREMENT AND PAYMENT

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications, and as directed by the Engineer.

END OF SECTION

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SECTION 26 07 50

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Electrical identification.

1.02 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with NFPA 70.

1.03 SUBMITTALS

- A. Shop Drawings: Dimensioned plans and Sections or elevation layouts of electrical equipment.

1.04 COORDINATION

- A. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- B. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

PART 2 - PRODUCTS

2.01 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ASME A13.1, NFPA 70, and these Specifications.
- B. Raceway and Cable Labels: Comply with ASME A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway and cable size.
 - 1. Type: Pretensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
 - 2. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is over-laminated with a clear, weather- and chemical-resistant coating.
 - 3. Color: Black letters on orange background.
 - 4. Legend: Indicates voltage.

5. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 1 IN wide by 3 mils thick.
- C. Underground Warning Tape: Permanent, bright-colored, continuous- printed, vinyl tape with the following features:
 1. Minimum 6 IN wide by 4 mils thick.
 2. Compounded for permanent direct-burial service.
 3. Embedded continuous metallic strip or core.
 4. Printed legend that indicates type of underground line.
- D. Tape Markers for Wire: Vinyl or vinyl cloth, self adhesive, wraparound type with preprinted numbers and letters.
 1. Color Coding Cable Ties: Type 6/6 nylon, self locking type. Colors to suit coding scheme.
- E. Engraved Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16 IN minimum thickness for signs up to 20 SQ IN and 1/8 IN minimum thickness for larger sizes. Engraved legend in black letters on white background.
- F. Interior Warning and Caution Signs: Comply with 29 CFR 1910.145.
- G. Preprinted, aluminum, baked enamel finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.
- H. Exterior Warning and Caution Signs: Comply with 29 CFR 1910.145.
- I. Weather resistant, nonfading, preprinted, cellulose acetate butyrate signs with 0.0396 IN galvanized steel backing, with colors, legend, and size appropriate to the application. 1/4 IN grommets in corners for mounting.
- J. Fasteners for Nameplates and Signs: Self tapping, stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 IDENTIFICATION INSTALLATION

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.

- C. Self Adhesive Identification Products: Clean surfaces before applying.
- D. Identify raceways and cables with color banding.
- E. Bands: Pretensioned, snap around, colored plastic sleeves or colored adhesive marking tape. Make each color band 2 IN wide, completely encircling conduit, and place adjacent bands of two color markings in contact, side by side.
 - 1. Band Locations: At changes in direction, at penetrations of walls and floors, at 50 FT maximum intervals in straight runs, and at 25 FT maximum intervals in congested areas.
 - 2. Colors:
 - a. Fire Alarm System: Red.
 - b. Security System: Blue and yellow.
 - c. Telecommunication System: Green and yellow.
- F. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color coding may be used for voltage and phase identification.
- G. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 6 to 8 IN below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 16 IN overall, use a single line marker.
 - 1. Color code 208Y/120-V system secondary service, feeder, and branch circuit conductors throughout the secondary electrical system as follows:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - 2. Color code 480Y/277-V system secondary service, feeder, and branch circuit conductors throughout the secondary electrical system as follows:
 - a. Phase A: Yellow.
 - b. Phase B: Brown.
 - c. Phase C: Orange.

- H. Install warning, caution, and instruction signs where required to comply with 29 CFR 1910.145, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal backed butyrate signs for outdoor items.
- I. Install engraved laminated emergency operating signs with white letters on red background with minimum 3/8 IN high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

PART 4 - MEASUREMENT AND PAYMENT

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications.

END OF SECTION

SECTION 26 08 00
ELECTRICAL TESTING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. General requirements for electrical field testing and inspecting.
 - 2. Detailed requirements are specified in each Section containing components that require testing. General requirements include:
 - a. Qualifications of testing agencies and their personnel.
 - b. Suitability of test equipment.
 - c. Calibration of test instruments.
 - d. Coordination requirements for testing and inspecting.
 - e. Reporting requirements for testing and inspecting.

1.02 REFERENCES

- A. International Electrical Testing Association (NETA):
 - 1. ATS, Standard for Acceptance Testing Specifications for Electric Power Equipment and Systems.
- B. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
 - 1. 455-78-B, Optical Fibers - PART 1-40: Measurement Methods and Test Procedures - Attenuation.

1.03 QUALITY ASSURANCE

- A. Testing Agency Qualifications:
 - 1. An independent firm performing, as the sole or principal part of its business for a minimum of 10 years, the inspection, testing, calibration, and adjusting of systems.
 - 2. Testing firm that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7 will be brought in by AUTHORITY to perform testing; Contractor will coordinate and cooperate with this group.

- B. Must have an established monitoring and testing equipment calibration program with accuracy traceable in an unbroken chain, according to NIST.
 - 1. Field personnel:
 - a. Minimum of one (1) year field experience covering all phases of electrical equipment inspection, testing, and calibration.
 - b. Relay test technician having previous experience with testing and calibration of relays of the same manufacturer and type used on project and proficient in setting and testing the types of protection elements used.
 - 2. Supervisor certified by NETA or NICET.
 - 3. Analysis personnel:
 - a. Minimum three (3) years combined field testing and data analysis experience.
 - b. Supervisor certified by NETA or NICET.
- C. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.
- D. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

PART 2 - MATERIALS - (NOT APPLICABLE TO THIS SECTION)

PART 3 - EXECUTION

3.01 GENERAL TESTS AND INSPECTIONS

- A. If a group of tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:
 - 1. Perform insulation-resistance tests.
 - 2. Perform continuity tests.
 - 3. Perform rotation test (for motors to be tested).
 - 4. Provide a stable source of single-phase electrical power for test instrumentation at each test location.
- B. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:
 - 1. Manufacturer's written testing and inspecting instructions.

2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
3. Tabulation of expected measurement results made before measurements.
4. Tabulation of "as-found" and "as-left" measurement and observation results.

PART 4 - MEASUREMENT AND PAYMENT

- A. Work of this Section is considered incidental to work under other payment items and no separate measurement and payment will be made to the Contractor for Work of this Section. Work of this section shall include furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications.

END OF SECTION

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SECTION 26 12 00

CONDUCTORS AND CABLES - LOW VOLTAGE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Material and installation requirements for:
 - a. Building wire.
 - b. Power cable.
 - c. Control cable.
 - d. Shielded VFD cable.
 - e. Instrumentation cable.
 - f. Fiber optic cable.
 - g. Wire connectors.
 - h. Insulating tape.
 - i. Pulling lubricant.
 - 2. Accessories required for a complete installation.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 01 - General Requirements.
 - 2. Section 01 33 00 - Submittal Procedures.
 - 3. Section 26 05 00 - Basic Electrical Materials and Methods.
 - 4. Section 26 08 00 - Electrical Testing
 - 5. Section 26 13 00 – Conduits, Raceways, and Boxes

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. 1202, Standard for Flame-Propagation Testing of Wire and Cable.

- B. Insulated Cable Engineers Association (ICEA):
 - 1. S-58-679, Standard for Control Cable Conductor Identification.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. ICS 4, Industrial Control and Systems: Terminal Blocks.
- D. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
 - 1. WC 57/S-73-532, Standard for Control Cables.
 - 2. WC 70/S-95-658, Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
- E. National Fire Protection Association (NFPA):
 - 1. 70, National Electrical Code (NEC).
 - 2. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- F. Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA):
 - 1. 598-C, Optical Fiber Cable Color Coding.
- G. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
 - 1. 568, Commercial Building Telecommunications Cabling Standard.
- H. Underwriters Laboratories, Inc. (UL):
 - 1. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
 - 2. 83, Standard for Safety Thermoplastic-Insulated Wires and Cables.
 - 3. 467, Standard for Safety Grounding and Bonding Equipment.
 - 4. 486A, Standard for Safety Wire Connectors and Soldering Lugs for use with Copper Conductors.
 - 5. 486C, Standard for Safety Splicing Wire Connections.
 - 6. 510, Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
 - 7. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

8. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.
9. 2250, Standard for Safety Instrumentation Tray Cable.

1.03 DEFINITIONS

- A. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.
- B. Instrumentation Cable:
 1. Multiple conductor, insulated, twisted or untwisted, with outer sheath.
 2. The following are specific types of instrumentation cables:
 - a. Analog signal cable:
 - 1) Used for the transmission of low current (e.g., 4-20mA DC) or low voltage (e.g., 0-10 Vdc) signals, using No. 16 AWG and smaller conductors.
 - 2) Commonly used types are defined in the following:
 - (1) TSP: Twisted shielded pair.
 - (2) TST: Twisted shielded triad.
 - b. Digital signal cable: Used for the transmission of digital signals between computers, PLC's, RTU's, etc.
- C. Power Cable: Multi-conductor, insulated, with outer sheath containing building wire, No. 8 AWG and larger.
- D. Control Cable: Multi-conductor, insulated, with outer sheath containing building wires, No. 14, No. 12 or No. 10 AWG.
- E. Building Wire: Single conductor, insulated, with or without outer jacket depending upon type.

1.04 SUBMITTALS

- A. Shop Drawings:
 1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

2. Product technical data:
 - a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
 - 1) Wire connectors.
 - 2) Insulating tape.
 - 3) Cable lubricant.
 - b. See Specification Section 26 05 00 for additional requirements.

1.05 QUALITY ASSURANCE

- A. Regulatory Requirements:
 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 2. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 1. Building wire, power and control cable and multiplex cable:
 - a. Aetna Insulated Wire.
 - b. Alphawire.
 - c. Cerrowire.
 - d. Encore Wire Corporation.
 - e. General Cable.
 - f. Okonite Company.
 - g. Southwire Company.
 - h. American Insulated Wire Corp., a Leviton Company.

2. Instrumentation cable:
 - a. Analog cable:
 - 1) Alphawire.
 - 2) Belden Inc.
 - 3) General Cable.
 3. Wire connectors:
 - a. AFC Cable Systems, Inc., div. Tyco Electrical and Metal Products.
 - b. Anderson Electrical Products, Inc., subsidiary Hubbell Incorporated
 - c. Burndy Corporation.
 - d. AMP brand, Tyco Electronics.
 - e. Buchanan.
 - f. Ideal.
 - g. Ilsco.
 - h. 3M Co.
 - i. Teledyne Penn Union.
 - j. Thomas and Betts.
 - k. Phoenix Contact.
 - l. O-Z/Gedney brand, EGS Electrical Group.
 4. Insulating and color coding tape:
 - a. 3M Co.
 - b. Plymouth Bishop Tapes.
 - c. Red Seal Electric Co.
- B. Submit request for substitution in accordance with Specification Section 01 25 00.

2.02 MANUFACTURED UNITS**A. Building Wire:**

1. Conductor shall be copper with 600 V rated insulation.
2. Conductors shall be stranded, except for conductors used in lighting and receptacle circuits which may be stranded or solid.
3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
4. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 for type THHN/THWN and THHN/THWN-2 insulation.
5. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 for type XHHW-2 insulation.

B. Power Cable:

1. Conductor shall be copper with 600 V rated insulation. 75 DegC temperature rated insulation. Where installed in raceway exposed to direct sunlight outside of the buildings, provide minimum 90 DegC temperature rated insulation.
2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
3. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 and UL 1277 for type THHN/THWN insulation with an overall PVC jacket.
4. Number of conductors as required, including a bare ground conductor.
5. Individual conductor color coding:
 - a. ICEA S-58-679, Method 4.
 - b. See PART 3 of this Specification Section for additional requirements.
6. Conform to NFPA 70 Type TC.

C. Control Cable:

1. Conductor shall be copper with 600 V rated insulation.
2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
3. Conform to NEMA/ICEA WC 57/S-73-532 and UL 83 and UL 1277 for type THHN/THWN insulation with an overall PVC jacket.

4. Number of conductors as required, provided with or without bare ground conductor of the same AWG size.
 - a. When a bare ground conductor is not provided, an additional insulated conductor shall be provided and used as the ground conductor (e.g., 6/c No. 14 w/g and 7/c No. 14 are equal).
 5. Individual conductor color coding:
 - a. ICEA S-58-679, Method 1, Table E-2.
 - b. See PART 3 of this Specification Section for additional requirements.
 6. Conform to NFPA 70 Type TC.
- D. Electrical Equipment Control Wire:
1. Conductor shall be copper with 600 V rated insulation.
 2. Conductors shall be stranded.
 3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
 4. Conform to UL 44 for Type SIS insulation.
 5. Conform to UL 83 for Type MTW insulation.
- E. Instrumentation Cable:
1. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
 2. Analog cable:
 - a. Tinned copper conductors.
 - b. 600 V PVC insulation with PVC jacket.
 - c. Twisted with 100 percent foil shield coverage with drain wire.
 - d. Six (6) twists per foot minimum.
 - e. Individual conductor color coding: ICEA S-58-679, Method 1, Table E-2.
 - f. Conform to UL 2250, UL 1581 and NFPA 70 Type ITC.
 3. Digital cable:
 - a. As recommended by equipment (e.g., PLC, RTU) manufacturer.

- b. Horizontal voice and data cable:
 - 1) Category 6 per TIA/EIA/ANSI 568.
 - 2) Cable shall be label-verified.
 - 3) Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level.
 - 4) Conductors: No. 24 AWG solid untinned copper.
 - 5) Rated CMP per NFPA 70.
- c. Conform to NFPA 262 and NFPA 70 Type ITC.

F. Fiber Optic Cables:

- 1. All multimode fiber optic cable, patch cords and connectors shall be colored orange. SC type connectors shall be used for all fiber optic cable connections. The fiber optic cable shall be multimode 850 nm, supplied by Corning Cable Systems or Approved equal and shall meet or exceed the following minimum specifications:
 - a. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical and mechanical requirements of the Work and environmental conditions encountered in Greater Los Angeles region.
 - b. Each optical fiber shall consist of a germania-doped silica core surrounded by a concentric glass cladding. The fiber shall be matched clad design.
 - c. Each optical fiber shall be proof tested by the manufacturer at a minimum of 100 KPSI.
 - d. Attenuation shall be ≤ 3.4 dB/Km.
 - e. Point discontinuity shall be ≤ 0.2 dB.
 - f. Effective modal bandwidth shall be ≥ 220 MHz-Km.
 - g. Cladding diameter shall be $125.0 + \text{ or } - 2.0 \mu\text{m}$ with a core diameter of $62.5 + \text{ or } - 3.0 \mu\text{m}$, and the coating diameter of $245 + \text{ or } - 5 \mu\text{m}$.

G. Wire Connectors:

- 1. Twist/screw on type:
 - a. Insulated pressure or spring type solderless connector.

- b. 600 V rated.
 - c. Ground conductors: Conform to UL 486C and/or UL 467 when required by local codes.
 - d. Phase and neutral conductors: Conform to UL 486C.
 - 2. Compression and mechanical screw type:
 - a. 600 V rated.
 - b. Ground conductors: Conform to UL 467.
 - c. Phase and neutral conductors: Conform to UL 486A.
 - 3. Terminal block type:
 - a. High density, screw-post barrier-type with white center marker strip.
 - b. 600 V and ampere rating as required, for power circuits.
 - c. 600 V, 20 ampere rated for control circuits.
 - d. 300 V, 15 ampere rated for instrumentation circuits.
 - e. Conform to NEMA ICS 4 and UL 486A.
- H. Insulating and Color Coding Tape:
 - 1. Pressure sensitive vinyl.
 - 2. Premium grade.
 - 3. Heat, cold, moisture, and sunlight resistant.
 - 4. Thickness, depending on use conditions: 7, 8.5, or 10 mil.
 - 5. For cold weather or outdoor location, tape must also be all-weather.
 - 6. Color:
 - a. Insulating tape: Black.
 - b. Color coding tape: Fade-resistant color as specified herein.
 - 7. Comply with UL 510.
- I. Pulling Lubricant: Cable manufacturer's standard containing no petroleum or other products which will deteriorate insulation.

PART 3 - EXECUTION**3.01 CONDUCTOR AND INSULATION APPLICATIONS****A. Installation:**

1. Permitted Usage of Insulation Types:
 - a. Building wire and power and control cable in architectural and non-architectural finished areas.
 - b. Building wire and power and control cable in conduit below grade.
2. Type XHHW:
 - a. Conductors from station power panel to TVM locations.
3. Type THHN/THWN and THHN/THWN-2:
 - a. Building wire and power and control cable No. 8 AWG and smaller in architectural and non-architectural finished areas.
4. Type SIS and MTW:
 - a. For the wiring of control equipment within control panels and field wiring of control equipment within switchgear, switchboards, motor control centers.

B. Conductor Size Limitations:

1. Feeder and branch power conductors shall not be smaller than No. 12 AWG unless otherwise indicated on the Drawings.
 - a. Solid copper type conductors for No. 12 AWG and No. 10 AWG.
2. Control conductors shall not be smaller than No. 14 AWG unless otherwise indicated on the Drawings.
3. Instrumentation conductors shall not be smaller than No. 18 AWG unless otherwise indicated on the Drawings.

C. Color Code All Wiring as Follows:

1. Building wire:

	240 V, 208 V, 240/120 V, 208/120 V	480 V, 480/277 V
Phase 1	Black	Brown
Phase 2	Red *	Orange
Phase 3	Blue	Yellow
Neutral	White	White or

Ground	Green	Gray Green
* Orange when it is a high leg of a 120/240 V Delta system.		

- a. Conductors No. 6 AWG and smaller: Insulated phase, neutral and ground conductors shall be identified by a continuous colored outer finish along its entire length.
- b. Conductors larger than No. 6 AWG:
 - 1) Insulated phase and neutral conductors shall be identified by one (1) of the following methods:
 - a) Continuous colored outer finish along its entire length.
 - b) 3 IN of colored tape applied at the termination.
 - 2) Insulated grounding conductor shall be identified by one (1) of the following methods:
 - a) Continuous green outer finish along its entire length.
 - b) Stripping the insulation from the entire exposed length.
 - c) Using green tape to cover the entire exposed length.
 - 3) The color coding shall be applied at all accessible locations, including but not limited to: Junction and pull boxes, wireways, manholes and handholes.
- 2. Power cables ICEA S-58-679, Method 4 with:
 - a. Phase and neutral conductors identified with 3 IN of colored tape, per the Table herein, applied at the terminations.
 - b. Ground conductor: Bare.
- 3. Control cables ICEA S-58-679, Method 1, Table E-2:
 - a. When a bare ground is not provided, one (1) of the colored insulated conductors shall be re-identified by stripping the insulation from the entire exposed length or using green tape to cover the entire exposed length.

- b. When used in power applications the colored insulated conductors used as phase and neutral conductors may have to be re-identified with 3 IN of colored tape, per the Table herein, applied at the terminations.
- D. Install all wiring in raceway unless otherwise indicated on the Drawings.
- E. Feeder, branch, control and instrumentation circuits shall not be combined in a raceway, cable tray, junction or pull box, except as permitted in the following:
 - 1. Where specifically indicated on the Drawings.
 - 2. Where field conditions dictate and written permission is obtained from the Engineer.
 - 3. Control circuits shall be isolated from feeder and branch power and instrumentation circuits but combining of control circuits is permitted.
 - a. The combinations shall comply with the following:
 - 1) 12 Vdc, 24 Vdc and 48 Vdc may be combined.
 - 2) 125 Vdc shall be isolated from all other AC and DC circuits.
 - 3) AC control circuits shall be isolated from all DC circuits.
 - 4. Instrumentation circuits shall be isolated from feeder and branch power and control circuits but combining of instrumentation circuits is permitted.
 - a. The combinations shall comply with the following:
 - 1) Analog signal circuits may be combined.
 - 2) Digital signal circuits may be combined but isolated from analog signal circuits.
 - 5. Multiple branch circuits for lighting, receptacle and other 120 Vac circuits are allowed to be combined into a common raceway.
 - a. Contractor is responsible for making the required adjustments in conductor and raceway size, in accordance with all requirements of the NFPA 70, including but not limited to:
 - 1) Up sizing conductor size for required ampacity de-ratings for the number of current carrying conductors in the raceway.
 - 2) The neutral conductors may not be shared.
 - 3) Up sizing raceway size for the size and quantity of conductors.

- F. Ground the drain wire of shielded instrumentation cables at one (1) end only.
 - 1. The preferred grounding location is at the load (e.g., control panel), not at the source (e.g., field mounted instrument).
- G. Splices and terminations for the following circuit types shall be made in the indicated enclosure type using the indicated method.
 - 1. Feeder and branch power circuits:
 - a. Device outlet boxes:
 - 1) Twist/screw on type connectors.
 - b. Junction and pull boxes and wireways:
 - 1) Twist/screw on type connectors for use on No. 8 and smaller wire.
 - 2) Compression, mechanical screw or terminal block or terminal strip type connectors for use on No. 6 AWG and larger wire.
 - c. Motor terminal boxes:
 - 1) Twist/screw on type connectors for use on No. 10 AWG and smaller wire.
 - 2) Insulated mechanical screw type connectors for use on No. 8 AWG and larger wire.
 - d. Manholes or handholes:
 - 1) Twist/screw on type connectors pre-filled with epoxy for use on No. 8 AWG and smaller wire.
 - 2) Watertight compression or mechanical screw type connectors for use on No. 6 AWG and larger wire.
 - 2. Control circuits:
 - a. Junction and pull boxes: Terminal block type connector.
 - b. Manholes or handholes: Twist/screw on type connectors pre-filled with epoxy.
 - c. Control panels and motor control centers: Terminal block or strips provided within the equipment or field installed within the equipment by the Contractor.

3. Instrumentation circuits can be spliced where field conditions dictate and written permission is obtained from the Engineer.
 - a. Maintain electrical continuity of the shield when splicing twisted shielded conductors.
 - b. Junction and pull boxes: Terminal block type connector.
 - c. Control panels and motor control centers: Terminal block or strip provided within the equipment or field installed within the equipment by the Contractor.
 4. Non-insulated compression and mechanical screw type connectors shall be insulated with tape or hot or cold shrink type insulation to the insulation level of the conductors.
- H. Insulating Tape Usage:
1. For insulating connections of No. 8 AWG wire and smaller: 7 mil vinyl tape.
 2. For insulating splices and taps of No. 6 AWG wire or larger: 10 mil vinyl tape.
 3. For insulating connections made in cold weather or in outdoor locations: 8.5 mil, all weather vinyl tape.

3.02 FIELD QUALITY CONTROL

- A. Testing: Perform each electrical test and visual and mechanical inspection stated in NETA ATS (Acceptance Testing Specifications), Section 7.3.1. Certify compliance with test parameters. See Specification Section 26 08 00.
- B. Test Reports: Prepare a written report to record:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Conductors and Cables for electrical and communications systems will be measured by the unit or fraction thereof furnished and completed in accordance with the Contract Documents and as measured by the Engineer. The quantities as contained on the Schedule of Quantities and Prices, or approved schedule of

values, as applicable, as derived from the Plans will be used as the basis for this measurement.

4.02 PAYMENT

- A. Conductors and Cables electrical and communications systems furnished and completed in accordance with the Contract Documents will be paid for at the Contract Unit Price, as listed on the Schedule of Quantities and Prices. This price shall include full compensation for furnishing all labor, Materials, tools, equipment, supplies, supervision, and incidentals, and doing all work, as shown on the Plans, and as specified in these Specifications.
- B. Work of this section shall include furnishing all acceptance testing, transportation, storage, assembly, delivery and incidentals as shown on the Plans, and as specified in these Specifications.

END OF SECTION

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