

SECTION 16130

RACEWAYS, BOXES AND CABINETS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.
- B. Related Work Specified Elsewhere:
 - 1. Underground electrical and communications distribution systems: Section 02585.
 - 2. Concrete formwork: Section 03100.
 - 3. Cast-in-place structural concrete: Section 03300.
 - 4. Structural precast concrete: Section 03400.
 - 5. Grounding and bonding: Section 16060.
 - 6. Firestopping: Section 07841.

1.02 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes and cabinets.
- B. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. National Electrical Code (NEC).
 - 3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
 - 4. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
 - 5. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - 6. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
 - 7. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled; A532/A532M-93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536-84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455-96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy

Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231-97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790-00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges (SSHB).
9. ITS: Directory of ITS listed products.

- C. The following items to be listed or labeled per referenced UL or ITS directory:
1. Conduit and fittings.
 2. Surface raceways and fittings.
 3. Underfloor raceways and fittings.
 4. Boxes.
 5. Cabinets.

1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings.
 2. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets and Fittings:
1. Size: As shown, minimum conduit size 3/4 inch.
 2. Materials:
 - a. Steel sheet: ASTM A507-00.
 - b. Zinc-coated steel sheet: ASTM A653/A653M-00.
 - c. Cast iron: ASTM A532/532M-93a(1999)e1.
 - d. Ductile iron: ASTM A536-84(1999)e1.
 - e. Malleable iron: ASTM A47/A47M-99.
 - f. Bronze extrusion: ASTM B455-96, Alloy C38500.

- g. Bronze casting: ASTM B584-00, Alloy C83600.
 - h. Rigid fiberglass reinforced epoxy: UL 1684.
 - i. Stainless steel: ASTM A276-00a, Type 304.
- 3. Zinc coating:
 - a. Hot-dip galvanizing: ASTM A123/A123M-00.
 - b. Electro galvanizing: ASTM B633-98.
- B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.
- C. Plastic Conduit and Fittings:
 - 1. PVC, UL 651, NEMA TC-2, Schedule 40 and 80 heavy-wall, for use with 90C conductors.
 - 2. Solvent cement: Manufacturer's standard.
- D. Aluminum Rigid Conduit and Fittings:
 - 1. ANSI C80.5 and UL 6.
- E. Liquid-Tight Flexible Conduit and Fittings:
 - 1. Applicable requirements of UL 360.
 - 2. Flexible galvanized-steel core with extruded liquid-tight neoprene or PVC jacket overall.
 - 3. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
 - 4. Sizes 1-1/2 inch and above provided with separate grounding conductor.
- F. Conduit Expansion Fittings and Expansion and Deflection Fittings:
 - 1. Materials:
 - a. For galvanized-steel rigid conduit:
 - 1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.
 - 2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve and stainless steel clamping bands.
 - b. For PVC conduit: Rigid metal expansion/deflection fitting with galvanized rigid steel to PVC conduit adapters at each end.
 - 2. Conduit expansion fitting: Weatherproof.
 - 3. Conduit expansion and deflection fitting: Watertight.
 - 4. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.
- G. Conduit Connector Fittings:
 - 1. UL 514B, material and finish similar to that of conduit with which they are to be used.
 - 2. For enclosures, cabinets, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.
 - 3. For enclosure, cabinets, boxes and gutters with hub in outdoor, tunnel and underground locations, except electrical rooms: Threaded watertight hub fitting with gasket.
 - 4. For enclosure having punched or formed knockout for conduit entry in outdoor and underground locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknut.
- H. Conduit and Cable-Seal Fittings:
 - 1. Conduit seal:
 - a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
 - b. Size as shown or necessary.

- c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.
 - d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
 - 2. Cable seal:
 - a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.
 - b. Size as necessary, drilled to accommodate cable.
 - c. Pressure discs of PVC-coated steel and sealing ring of neoprene.
 - d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.
 - 3. Seal compound:
 - a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.
 - b. Pour-type for horizontal and gun-grade for vertical or overhead application.
 - c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40F to plus 150F without loss of watertight seal.
 - d. Pot life: 15 minutes.
 - e. Minimum ambient temperature for application: 35F.
 - f. Initial cure: 15 minutes.
 - g. Final cure: Seven days.
 - h. Hardness, Durometer A: 20-35.
 - i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
 - j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.
 - k. Fox Industries, Type FX-571G or approved equal.
- I. Conduit and Cable Supports:
 - 1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:
 - a. Type, style and size: As necessary.
 - b. Material and finish: Stainless steel, Type 304, or approved equal.
 - c. For separating conduit from masonry surface: Hot-dip galvanized malleable-iron spacer assembled with Style A strap.
 - d. For vertical run of metallic-sheath cable: Basket-weave cable support.
 - e. For fastening conduit or cable to channel inserts: Stainless steel, Type 304, or approved equal.
 - 2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:
 - a. Material and finish: Stainless steel, Type 304, or approved equal.
 - b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
 - c. Horizontal member: Channel, 1-1/2 inches square or 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.
 - d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.
 - 3. Channel inserts:

- a. Size and shape as shown, 12 gauge or heavier stainless steel, Type 304, or approved equal, with 7/8-inch wide slot.
 - b. For surface mounting: Channel inserts with 9/16-inch base slot, eight inches on center with minimum pullout-load rating of 1,000 pounds per linear foot.
 - 4. Spot inserts: Rated 800 pounds with safety factor of five, fabricated from steel galvanized after fabrication, covered to prevent entrance of concrete during installation.
- J. Surface Raceways and Fittings: UL 5, fabricated from galvanized steel.
- K. Underfloor Raceways and Fittings:
 - 1. UL 884.
 - 2. Size: As shown.
 - 3. Fabricated from steel 14 gauge or heavier steel sheet.
 - 4. Finish: Corrosion-resistant coating listed per referenced UL or ITS directory.
- L. Boxes and Cabinets:
 - 1. Outlet boxes:
 - a. UL 514A, capable of accommodating conduit as shown.
 - b. Material and finish:
 - 1) Steel, malleable iron, cast iron or ductile iron.
 - 2) Hot-dip galvanized or electro galvanized after fabrication.
 - c. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
 - d. For outdoor and underground locations, except electrical rooms:
 - 1) Threaded-conduit entrance hub.
 - 2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for enclosures having punched or formed knockouts for conduit entry.
 - e. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 inch square by 1-1/2 inch deep.
 - f. For floor receptacles: Watertight cast-iron outlet boxes, four inches diameter, of suitable depth and complete with the following:
 - 1) Adjustment screws for final leveling.
 - 2) Bronze floor plate with flush-mounted screw plug, without exposed fastener, M32 finish.
 - 3) Screw plug attached to outlet-box assembly by chain or other means, M32 finish.
 - 4) Bronze floor plate flange, five inches in diameter, extending beyond box 1/2-inch above finished floor, M32 finish.
 - 5) One special screw-plug removal tool with every 10 receptacles.
 - g. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, three-inch diameter, of suitable depth and complete with the following:
 - 1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.
 - 2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.
 - 3) Bronze faceplate flange, five inches in diameter, extending beyond box, M32 finish.
 - 4) One special screw-plug removal tool with every 10 receptacles.
 - 2. Junction and pull boxes:
 - a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.
 - b. Flush-mounted or surface-mounted as shown.

- c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.
- d. Material and finish:
 - 1) Metallic boxes:
 - a) Steel, malleable iron, cast iron or ductile iron.
 - b) Hot-dip galvanized or electro galvanized after fabrication.
 - c) Stainless steel in tunnel areas.
 - 2) Non-metallic boxes:
 - a) Precast concrete: Compressive strength 3,500 psi; air entrainment six-percent minimum, ASTM C173-94ae1 or C231-97e1; Section 03300 and Section 03400 and in accordance with the following:
 - 1) Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown.
 - 2) Cover:
 - (a) Material same as for box. Use of metallic cover and cover frame prohibited.
 - (b) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
 - (c) Non-protruding provisions provided for lifting.
 - 3) Reinforcement:
 - (a) Sidewalk and landscape locations: Welded wire fabric, ASTM A185-97.
 - (b) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M-00.
 - 4) Loading:
 - (a) Sidewalk and landscape locations: AASHTO 's SSHB H15-44.
 - (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
 - (c) Hardware: Stainless steel.
 - (d) Size: As shown or next available larger size.
 - b) Composite material: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Method
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water Absorption (24 hours)	0.5 percent	ASTM D570

- 1) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

- 2) Cover:
 - (a) Material same as for box.
 - (b) Skid-resistant top surface with minimum 0.5 coefficient of friction.
 - (c) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
 - (d) Secured to box with bolts.
 - (e) Non-protruding provisions provided for lifting.
 - 3) Loading:
 - (a) Sidewalk and landscape locations: AASHTO's SSHB H15-44.
 - (b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.
 - 4) Hardware: Stainless steel.
 - 5) Size: As shown or next available larger size.
- c) Molded fiberglass-reinforced polyester 1/8-inch thickness, minimum, and in accordance with the following requirements:

Physical Properties	Values	Method
Flexural strength	17,000 psi	ASTM D790
Deflection temperature	400F	ASTM D648
Water absorption (24 hours)	0.5 percent	ASTM D570
Tensile strength	6,500 psi	ASTM D638
Specific gravity	1.8	ASTM D794
Flammability	94-5V	UL 94
Dielectric strength	400 volts per mil	ASTM D149
Arc resistance	180 seconds	ASTM D495

- 1) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry-film thickness on both inside and outside surfaces.
 - 2) Color: Fiberglass material, gray inside and outside.
 - d) Molded polyvinyl chloride 1/8-inch thickness, minimum.
- e. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
- f. For outdoor and underground locations, except electrical rooms:
- 1) Threaded conduit entrance hub.
 - 2) Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknuts for boxes having punched or formed knockouts for conduit entry.
3. Cabinets:

- a. UL 50, fabricated from galvanized steel.
 - b. Surface-mounted, unless otherwise shown.
 - c. Backplate of reinforced steel for mounting interior components and to ensure rigid support and accurate alignment.
 - d. Provision for cabinet grounding.
 - e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
 - f. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and coated after fabrication with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
- M. Cable Trays:
- 1. NEMA VE1, ventilated-steel ladder-type.
 - 2. Dimensions: Three inches inside depth; nine inches rung spacing unless otherwise shown.
 - 3. Maximum load rating: 50 pounds per linear foot with safety factor of 1.5 at 12-foot support span.
 - 4. Bend radius:
 - a. For incoming service cable: As required by power company.
 - b. For all other cable: 24 inches or as necessary and approved.
 - 5. Finish: Cable trays, fittings and accessories hot-dip galvanized or electro galvanized after fabrication.
- N. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304, or approved equal.
- O. Data-Transmission System (DTS) Cabinet:
- 1. Wall-mounted, single-door, NEMA 250 Type 12, with panel, Hoffman Engineering Company, as shown, or approved equal.
 - 2. Enclosure: Formed of minimum 14-gauge steel, seams continuously welded and ground, without openings or knockouts, with threaded-conduit entrance hubs, lugs for mounting enclosure and collar studs for mounting panel. Rolled lip formed on all sides of door opening. Enclosure and door reinforced when size exceeds 30 inches square. Size as shown.
 - 3. Door: Formed of minimum 14-gauge steel, with rolled lip along top and sides to mate with enclosure. Fitted with removable print pocket. Closed-cell neoprene gasket attached with oil-resistant adhesive and steel retaining clips.
 - 4. Hardware: Corrosion-resistant steel continuous piano hinge with removable pin. Hasp and staple for padlocking.
 - 5. Panel: Formed of 12-gauge steel.
 - 6. Finish: Galvanized enclosure, door, panel and latch mechanism. Prepared for painting by manufacturer's standard method in accordance with the following:
 - a. Outside: Phosphatized, primed and finished with two coats of light-gray enamel or epoxy coating, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
 - b. Inside including panel: Two coats of white enamel or epoxy coating.
 - 7. Breather drain: One 1/2-inch diameter, Crouse-Hinds Catalog No. ECD11, or approved equal.
 - 8. Grounding stud: Manganese bronze, ASTM B138-96, Alloy No. 675 hard, 3/8-inch high; Evedur GSI, American Brass Company or approved equal.
 - 9. Terminations: Assembly rail and modular terminals, Weidmuller Terminations, Incorporated or approved equal.
 - a. Terminal: Modular test terminal, Melamine plastic, screw-clamp connections, with socket screws; Type SAKC4, Catalog No. 3406.2 or approved equal, with the following additional requirements:
 - 1) Amperes: 25.

- 2) Volts: 300.
- 3) Wire-gauge range: 22AWG to 12AWG.
- 4) Thickness: 0.256 inch.
- 5) Listed per referenced UL or ITS directory.
- 6) Standard accessories; compatible with terminal, with the following additional requirements:
 - a) End section: Type AP, No. 1179.2 or approved equal.
 - b) End bracket: Type EWK1, No. 2061.6 or approved equal.
 - c) Test plug: Type PS, No. 1804.0 or approved equal.
 - d) Cross-connection combination: QB25, No. 91455.D or approved equal.
 - e) Disconnect plug for SAKC4 terminal: Type TST, No. 3399.0 or approved equal.
- b. Assembly rail: Type TS32 steel standard section compatible with terminals, with fixing slots, Catalog No. 1228.0 and standard rail-mounting screws or approved equal.
- c. Marking tags: Dekafix 6.5-FS or approved equal, consecutive vertical, Number 4682.6 or Number 5766.6 as approved. Consecutive numbering conforming to that of DTS box.
- d. Group marking carrier with paper marking strip and transparent cover.
 - 1) Type SCHAT5, Catalog No. 2924.6 or approved equal.
 - 2) Type ESO5, Catalog No. 2937.0 or approved equal.
 - 3) SST5, Catalog No. 2940.0 or approved equal.

P. Fiberglass Conduit and Fittings:

1. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
2. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.
3. IPS based conduit with nominal wall thickness of 0.09 inches for five-inch nominal conduit size.
4. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
5. Conduit sections formed with integral bell and spigot type couplings. Rubber sealing gasket at bell end is prohibited.
6. Conduits, elbows and fittings provided with protection from exposure to sunlight by pigmentation uniformly dispersed through resin material.
7. Adhesive as recommended by conduit manufacturer.
8. Conduits, elbows and fittings are specified for use throughout a temperature range of -40°F to 230°F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.
9. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 347 for Rigid Nonmetallic Conduit and its use.
10. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, mark clearly legible and durable every 10 feet or as recommended by the manufacturer.
 - a. "Reinforced Thermosetting Resin Conduit", "RTRC"; "Fiberglass Reinforced Epoxy Conduit", "FREC"; or equivalent, as applicable.
 - b. Normal Size: (IPS)
 - c. Manufacturer's name and trademark.
 - d. Temperature range for conduit application.
 - e. "Above Ground", "AG", "Below Ground", "BG", or equivalent wording, as applicable.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. General:
1. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
 2. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
 3. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, nonabsorptive tape or coating to prevent corrosion.
 4. Make metallic conduit, raceways, ducts and cable trays, electrically and mechanically continuous and ground them in accordance with Section 16060.
 5. Install FRE conduit where conduit runs are embedded in concrete and where conduit is shown as direct-burial.
- B. Conduit:
1. Run exposed conduit parallel to building lines.
 2. Install exposed conduit to avoid interference with other work.
 3. Traction-power substations, tie-breaker stations, ac-switchboard, electrical, train-control, communication and mechanical rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits in contact with concrete and seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:
 - a. Where shown and as necessary, install cable seal and conduit seal in accordance with the manufacturer's recommendations.
 - b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:
 - 1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.
 - 2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.
 - 3) Use FRE sleeve for conduit seal installed on traction-power, train-control and communication conduit.
 - c. For 34.5 kv incoming-service cable with concentric neutral, install cable seal in traction-power substations, ac-switchboard rooms and 34.5 kv utility company manholes adjacent to WMATA facilities in accordance with the following requirements:
 - 1) Do all work in coordination with a utility company representative.
 - 2) Install O-Z CSBI cable seal at each end of the conduit for the service entrance cables (one at the last utility company manhole and one at the WMATA facility entrance). Use torque recommended by manufacturer for this type of cable seal, do not over-torque.
 - d. For 13.8 kv incoming-service cable, install cable seal in traction-power substation, ac-switchboard rooms and utility company manholes adjacent to WMATA facilities. Coordinate the work with utility company representative.
 - e. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.
 - f. All conduits free of water before conduit seals are installed.
 4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.

5. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.
6. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.
7. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.
8. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.

9. Bends:

- a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
- b. Install bends in buried conduit in accordance with the following:

Size of Conduit (in inches)	Minimum Radius of Factory-Bend (in inches)	Minimum Radius of Field-Bend (in inches)
3	18	24
4	24	30
5	48	48
6	48	48

- c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
 - d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
10. Support conduit during construction to prevent distortion and to ensure independent support.
 11. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
 12. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
 13. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.
 14. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.
 15. Support conduit above suspended ceiling using applicable specified methods.
 16. Install conduit so as to drain moisture to nearest outlet or pull box.
 17. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.
 18. Do not use wire for support of conduit and cable.
 19. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.
 20. Buried FRE conduit: Install in accordance with the following requirements in addition to those specified elsewhere:
 - a. Arrange conduit to cross each expansion joint at right angle to joint.
 - b. Prevent concrete and other materials from obstructing the conduit. Pack outlets, pull boxes and junction boxes and cap conduit ends prior to pouring concrete.
 - c. Use Tight Lock Joint method to join conduit sections for providing water tightness and pull out strength.

- d. Provide compatible conduit supports and spacers to maintain position of conduit during placement of concrete.
 - e. Install buried non-metallic conduit for cable over 600 volts in accordance with reference code.
 - f. Waterproof conduit connections.
 - g. Rod and swab conduit after installation so as to remove water, cement and other foreign matter; cap conduit ends. If obstructions cannot be removed or if condition exists which may result in damage to cable, replace conduit.
 - h. Leave approved nylon or polyester pull-line in each conduit.
 - 21. Use metallic conduit or above ground FRE conduit in exposed locations.
 - 22. Conduit installed in outdoor location: Waterproof conduit connection.
 - 23. Use IPS FRE conduit for all concrete-encased applications except as follows:
 - a. Use FRE conduit with minimum wall thickness of 0.95 inch for train control conduit direct buried without concrete encasement where shown.
 - b. Install conduits encased in concrete ductbanks, associated manholes and handholes outside the structural work in accordance with Section 02585.
- C. Channel Inserts and Spot Inserts:
- 1. Surface-mount channel inserts as shown.
- D. Surface Raceways:
- 1. Install as shown.
- E. Underfloor Raceways:
- 1. Install underfloor raceways as specified in Section 03100. Align and level raceways accurately. Hold raceways in place during placing of concrete.
- F. Outlet, Junction and Pull Boxes:
- 1. Mount outlet boxes as shown.
 - 2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.
 - 3. Keep number of knock-outs to minimum.
 - 4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
 - 5. Install covers on boxes mounted on walls and ceilings.
 - 6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.
 - 7. Fasten floor boxes securely in place.
 - 8. Install junction and pull boxes so that covers are readily accessible.
 - 9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.
 - 10. Use stainless steel (Type 304) mounting channels, retaining straps and fasteners, pipe hangers for conduits and cables; expansion bolt anchors, junction boxes, outlet boxes, cover plates for receptacles, enclosures for load centers in tunnel environment which includes vent and fan shafts and underplatform areas.
 - 11. Use non-metallic boxes as follows:
 - a. Buried with cover flush-mounted with finish grade: Precast concrete or composite material junction and pull boxes within AASHTO load designations as specified.
 - b. For indoor and outdoor locations not subject to pedestrian or vehicular traffic: Molded fiberglass-reinforced polyester junction and pull boxes.
 - c. For outdoor locations but not for burial: Molded polyvinyl chloride junction and pull boxes.
- G. Cabinets:
- 1. Fasten cabinet securely using expansion bolts, toggle bolts or mounting ears.
 - 2. Touch-up damaged painted finish.

- H. Cable Trays:
 - 1. Install cable trays neatly, adequately supported and as shown.
 - 2. For incoming-service cable from power company, install cable tray as approved by the power company.
- I. Use expansion-bolt anchors to secure equipment to concrete surfaces.
- J. Attachments to Prestressed-Concrete Girders:
 - 1. Attach pipes, conduits, boxes or similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except for track fasteners and appurtenances as shown.
- K. DTS Cabinet and Terminals:
 - 1. Install as shown.
- L. Car Wash Areas:
 - 1. Use PVC-coated galvanized steel conduit.

3.02 FILLING OF OPENINGS:

- A. Where conduit and raceway pass through fire-rated walls, ceilings or floors, provide seals to prevent passage of fire and fumes and to maintain integrity of fire-rated structure in accordance with Section 07481.
- B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes in accordance with Section 07841.
- C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.03 IDENTIFICATION:

- A. At end of each run, use stainless steel or aluminum tags, minimum 1-1/2 inch diameter, with stamped markings, minimum 1/4-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.
- B. Identify by red painted color code and by marking EMERGENCY SYSTEM on all boxes and enclosures for emergency circuits to identify them as part of an emergency system in accordance with the NEC.

3.04 FIELD QUALITY CONTROL:

- A. Arrange with the Engineer for inspection and approval of embedded conduit and boxes prior to concrete placement.
- B. Arrange with the Engineer for inspection by electrical utility company representative of incoming-service conduit prior to placing concrete.

- C. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Engineer.
- D. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of Engineer.
- E. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

END OF SECTION