

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - c. C80.3, Steel Electrical Metallic Tubing (EMT).
 - d. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - e. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - f. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - g. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - h. VE 1, Metallic Cable Tray Systems.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

7. UL:
- a. 1, Standard for Safety for Flexible Metal Conduit.
 - b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
 - c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
 - d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
 - e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
 - g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
 - j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
 - k. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
 - l. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Manufacturer's Literature:
 - a. Rigid galvanized steel conduit.
 - b. Electric metallic tubing.
 - c. PVC Schedule 40 conduit.
 - d. PVC Schedule 80 conduit.
 - e. PVC-coated rigid galvanized steel conduit.
 - f. Flexible metal, liquid-tight conduit.
 - g. Flexible, nonmetallic, liquid-tight conduit.
 - h. Flexible metal, nonliquid-tight conduit.
 - i. Conduit fittings.
 - j. Wireways.
 - k. Surface metal raceway.
 - l. Device boxes for use in hazardous areas.
 - m. Junction and pull boxes used at or below grade.
 - n. Large junction and pull boxes.
 - o. Terminal junction boxes.
- 2. Precast Manholes and Handholes:
 - a. Dimensional drawings and descriptive literature.
 - b. Traffic loading calculations.
 - c. Accessory information.

3. Telecommunications Pathway Cable Tray:
 - a. Dimensional drawings, calculations, and descriptive information.
 - b. NEMA load/span designation and how it was selected.
 - c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
 - d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
 - e. Layout drawings and list of accessories being provided.
4. Cable Tray Systems:
 - a. Dimensional drawings, calculations, and descriptive information.
 - b. NEMA load/span designation and how it was selected.
 - c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
 - d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
 - e. Layout drawings and list of accessories being provided.
5. Equipment and machinery proposed for bending metal conduit.
6. Method for bending PVC conduit less than 30 degrees.
7. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
8. Conduit Layout:
 - a. Under Slab Conduits: Provide drawings or sketches of under slab conduits at each facility prior to pouring of concrete foundations and slabs. Contractor shall submit drawings or sketches a minimum of 30 days prior to planned installation. Intent is to coordinate under slab conduit layout between other disciplines prior to pour and to provide a record of under slab conduit layout after construction. Drawings or sketches shall include all stub up locations and shall be constructed using drawing backgrounds from Contract Documents.
 - b. Bioreactor Conduits: Provide drawings or sketches on planned conduit routing on bioreactors. Submittal shall include concept of planned conduit routing from the electrical room to device locations, including information on Contractor's concept for mounting and racking conduits on the reactor structure and walkways. Contractor shall submit drawings or sketches a minimum of 30 days prior to planned installation.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization in order to provide a basis for approval under NEC.
- B. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.
- C. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 RIGID GALVANIZED STEEL CONDUIT

- A. Physical Characteristics: Hot-dip galvanized with chromated protective layer.
- B. Functional Characteristics: NEMA C80.1 and UL 6.
- C. Performance Characteristics: None.

2.02 RIGID GALVANIZED STEEL CONDUIT FITTINGS

- A. Physical Characteristics: None.
- B. Functional Characteristics:
 - 1. General:
 - a. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
 - 2. Bushings:
 - a. Malleable iron.
 - b. Integral insulated throat, rated for 150 degrees C.
 - 3. Grounding Bushings:
 - a. Malleable iron.
 - b. Integral insulated throat, rated for 150 degrees C.
 - c. Solderless lugs.
 - 4. Conduit Hubs: UL listed for use in wet locations.
 - 5. Conduit Bodies: Sized as required by NFPA 70.
 - 6. Unions: Concrete-tight, hot-dip galvanized malleable iron.

- 7. Cable sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For conductors with outer diameter of 0.50-inch or less:
Polychloroprene bushing at connector entry.

C. Performance Characteristics: None.

2.03 RIGID ALUMINUM CONDUIT

A. Physical Characteristics: None.

B. Functional Characteristics:

- 1. NEMA 80.5 and UL 6A.
- 2. Type 6063, copper-free aluminum alloy.

C. Performance Characteristics: None.

2.04 RIGID ALUMINUM CONDUIT FITTINGS

A. Physical Characteristics: None.

B. Functional Characteristics:

- 1. General:
 - a. Type: Threaded, copper-free. Set screw fittings not permitted.
- 2. Insulated Bushing:
 - a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
- 3. Grounding Bushing:
 - a. Material: Cast aluminum with integral insulated throat.
- 4. Conduit Hub:
 - a. Material: Cast aluminum, with insulated throat.
- 5. Cable Sealing Fittings:
 - a. Bushing: Polychloroprene at connector entry.

C. Performance Characteristics: None.

2.05 ELECTRIC METALLIC TUBING (EMT)

A. Physical Characteristics: Hot-dip galvanized with chromated and lacquered protective layer.

B. Functional Characteristics: NEMA 80.3 and UL 797.

C. Performance Characteristics: None.

2.06 ELECTRIC METALLIC TUBING (EMT) FITTINGS

A. Physical Characteristics: None.

B. Functional Characteristics:

1. Meet requirements of UL 514B.
2. Raintight.
3. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
4. Electro zinc-plated inside and out.

C. Performance Characteristics: None.

2.07 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC)

A. Physical Characteristics:

1. Material: Galvanized steel with extruded PVC jacket.

B. Functional Characteristics: UL 360 listed for 105 degrees C insulated conductors.

C. Performance Characteristics: None.

2.08 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) FITTINGS

A. Physical Characteristics: None.

B. Functional Characteristics:

1. Metal insulated throat connectors with integral nylon or plastic bushing.
2. Insulated throat and sealing O-rings.

C. Performance Characteristics: None.

2.09 NONLIQUID-TIGHT FLEXIBLE METALLIC CONDUIT

A. Physical Characteristics:

1. Material: Galvanized steel.

B. Functional Characteristics: Meet requirements of UL 1.

C. Performance Characteristics: None.

2.10 NONLIQUID-TIGHT FLEXIBLE METALLIC CONDUIT FITTINGS

- A. Physical Characteristics: None.
- B. Functional Characteristics:
 - 1. Body: Galvanized steel or malleable iron.
 - 2. Throat: Nylon insulated.
 - 3. 1-1/4-Inch Conduit and Smaller: One screw body.
 - 4. 1-1/2-Inch Conduit and Larger: Two screw body.
- C. Performance Characteristics: None.

2.11 POLYVINYL CHLORIDE (PVC) CONDUIT, SCHEDULE 40

- A. Physical Characteristics: None.
- B. Functional Characteristics:
 - 1. Type: PVC, slip-on.
 - 2. Meet requirements of NEMA TC 2 and UL 651.
 - 3. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
- C. Performance Characteristics: None.

2.12 INNERDUCT

- A. Physical Characteristics:
 - 1. Color: Orange.
 - 2. Smooth or corrugated high-density polyethylene (HDPE).
- B. Functional Characteristics: Resistant to spread of fire, per requirements of UL 2024
- C. Performance Characteristics: None.

2.13 WATERTIGHT CONDUIT ENTRANCE SEAL DEVICES

- A. Physical Characteristics: None.
- B. Functional Characteristics:
 - 1. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.

2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.

C. Performance Characteristics: None.

2.14 OUTLET AND DEVICE BOXES

A. Physical Characteristics:

1. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.
2. Cast Metal:
 - a. Box: Malleable iron or cast ferrous metal.
 - b. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
 - c. Hubs: Threaded.
 - d. Lugs: Cast Mounting.
3. Cast Aluminum:
 - a. Material:
 - 1) Box: Cast, copper-free aluminum.
 - 2) Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
 - b. Hubs: Threaded.
 - c. Lugs: Cast mounting.
4. PVC-Coated Cast Metal:
 - a. Type: One-piece.
 - b. Material: Malleable iron, cast ferrous metal, or cast aluminum.
 - c. Coating:
 - 1) Exterior Surfaces: 40-mil PVC.
 - 2) Interior Surfaces: 2-mil urethane.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.15 SHEET STEEL BOXES

A. Physical Characteristics:

1. Box: Code-gauge, galvanized steel.
2. Cover: Full access, screw type.
3. Machine Screws: Corrosion-resistant.
4. Finish: Manufacturer's standard.
 - a. Box interior: White.
 - b. Exterior: Dark gray.

- B. Functional Characteristics: NEMA 250, Type 4.
- C. Performance Characteristics: None.

2.16 STAINLESS-STEEL BOXES

- A. Physical Characteristics:
 - 1. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel, with white enamel painted interior mounting panel.
 - 2. Cover: Hinged with clamps.
 - 3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
- B. Functional Characteristics: NEMA 250 Type 4X.
- C. Performance Characteristics: None.

2.17 NON-METALLIC BOXES

- A. Physical Characteristics:
 - 1. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
 - 2. Cover: Hinged with clamps.
 - 3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
- B. Functional Characteristics:
 - 1. NEMA 250 Type 4X.
 - 2. Provide conduit hubs and mounting lugs.
- C. Performance Characteristics: None.

2.18 TELEPHONE AND DATA OUTLETS

- A. Physical Characteristics: None.
- B. Functional Characteristics: Provide outlet boxes and cover plates meeting requirements of TIA 569B.
- C. Performance Characteristics: None.

2.19 TERMINAL JUNCTION BOX

- A. Physical Characteristics:
 - 1. Interior: White.

B. Functional Characteristics:

1. Cover: Hinged.
2. Terminal Blocks:
 - a. Separate connection point for each conductor entering or leaving box.
 - b. Spare terminal points: 50 percent, minimum.

C. Performance Characteristics: None.

2.20 METAL WIREWAYS

A. Physical Characteristics:

1. Type: Steel-enclosed, lay-in type.
2. Cover: Hinged with friction latch.
3. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
4. Knockouts: Without knockouts, unless otherwise indicated

B. Functional Characteristics:

1. Meet requirements of UL 870.
2. Rating: Indoor.

C. Performance Characteristics: None.

2.21 PRECAST HANDHOLES

A. Physical Characteristics:

1. Material: Concrete.
 - a. Strength: Minimum, 3,000 psi compressive, in 28 days.
2. Nominal Dimensions: 4-feet wide, 4-feet long, and 4-feet deep, unless otherwise noted.
3. Access: Provide cast concrete 6-inch or 12-inch risers and adapters between top of manhole and finished grade at required elevations.
4. Embedded Pulling Iron:
 - a. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
 - b. Location:
 - 1) Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
 - 2) Floor: Centered below manhole or handhole cover.

5. Cable Racks:
 - a. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
 - b. Wall Attachment:
 - 1) Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
 - 2) Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
6. Furnish knockout for ground rod in floor of each handhole.
7. Handhole Frames and Covers:
 - a. Material: Hot-dipped galvanized steel.
 - b. Hardware: Hot-dipped galvanized steel.
 - c. Cover Type: Solid, bolt-on, nonskid design.
 - d. Cover Designation:
 - 1) Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
 - a) 600 Volts and Below: ELECTRIC LV.
 - b) DATA.

B. Functional Characteristics:

1. Loading: AASHTO, H-20 in accordance with ASTM C857.
2. Drainage:
 - a. Slope floors toward drain points, leaving no pockets or other nondraining areas.
 - b. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.
3. Raceway Entrances:
 - a. Provide on all four sides.
 - b. Provide knockout panels or precast individual raceway openings.
 - c. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.
4. Handhole Frames and Covers:
 - a. Cover Loading: AASHTO H-20.

C. Performance Characteristics: None.

2.22 DUCT BANK SPACERS

A. Physical Characteristics:

1. Modular Type:
 - a. Nonmetallic, interlocking, for multiple conduit sizes.
 - b. Suitable for all types of conduit.
2. Template Type:
 - a. Nonmetallic, custom made one-piece spacers.
 - b. Suitable for all types of conduit.
 - c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
 - d. Conduit openings cut 1 inch larger than conduit outside diameter.
 - e. Additional openings for stake-down, rebar, and concrete flow through as required.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.23 RACEWAY TAGS

A. Physical Characteristics:

1. Material: Permanent, nonferrous metal.
2. Shape: Round.

B. Functional Characteristics:

1. Raceway Designation: Pressure stamped, embossed, or engraved.
2. Tags relying on adhesives or taped-on markers not permitted.

C. Performance Characteristics: None.

2.24 WARNING TAPE

A. Physical Characteristics:

1. Material: Polyethylene, 4-mil gauge with detectable strip.
2. Color: Red.
3. Width: Minimum 6 inches.
4. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.

B. Functional Characteristics:

1. Designation: Warning on tape that electric circuit is located below tape.

C. Performance Characteristics: None.

2.25 HEAT SHRINKABLE TUBING

A. Physical Characteristics:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Color: Black.

B. Functional Characteristics: Semi-flexible with meltable adhesive inner liner.

C. Performance Characteristics: None.

2.26 WRAPAROUND DUCT BAND

A. Physical Characteristics:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

- I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- M. Install watertight fittings in outdoor, underground, or wet locations.
- N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- P. Do not install raceways in concrete equipment pads, foundations, or beams without Contracting Officer approval.
- Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

- A. Where the Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.
 - 1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
 - 2. Conduit is sized per the NEC.
 - 3. Conduit is of the type specified in Contract Documents.
 - 4. Conduit is supported as specified in Contract Documents.
- B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

- A. Minimum Cover: 2 inches, including fittings.
- B. Conduit placement shall not require changes in reinforcing steel location or configuration.
- C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
- D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Contracting Officer.
- E. Slabs and Walls (Requires Contracting Officer Approval):
 - 1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
 - 2. Install within middle two-fourths of slab or wall.
 - 3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
 - 4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
 - 5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
 - 6. Separate conduit by a minimum 6 times the outside dimension of expansion/deflection fittings at expansion joints.
 - 7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.
- F. Columns and Beams (Requires Contracting Officer Approval):
 - 1. Trade size of conduit not to exceed one-fourth of beam thickness.
 - 2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

- A. Diameter: Minimum 3/4 inch.
- B. Refer to Area and Material Classification Sheets on the Drawings for conduit applications, unless otherwise indicated below.
 - 1. Direct Earth Burial: PVC Schedule 40.
 - 2. Concrete-Encased Duct Bank: PVC Schedule 40.
 - 3. Under Slabs-On-Grade: PVC Schedule 40.
 - 4. Above Acoustical Tile Ceilings: EMT.
 - 5. Stud Framed Walls: EMT.
 - 6. Concrete Block or Brick Walls: PVC Schedule 40.

7. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.
8. Under Equipment Mounting Pads: PVC Schedule 40 conduit.
9. Exterior Light Pole Foundations: PVC Schedule 40.

3.05 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Contracting Officer where flexible connection is required to minimize vibration:
 1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
 2. Conduit Size Over 4 Inches: Nonflexible.
 3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight.
 4. Dry Areas: Flexible, metallic liquid-tight.
 5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and Division 2 areas.
- B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.
- D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.06 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating using fire penetration seal as specified in Section 07 92 00, Joint Sealants
- D. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal.
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side.
 - c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer.
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment.
 - c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Corrosive-Sensitive Areas:
 - a. Seal conduit passing through room walls.
 - b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
 - c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
 - a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
 - a. Metallic Raceways: Provide insulated grounding bushings.
 - b. Nonmetallic Raceways: Provide bell ends flush with wall.
 - c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 8 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 15 percent extra space for future conduit.
- C. Application/Type of Conduit Strap:
 - 1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
 - 2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
 - 3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.
- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 - 1. Wood: Wood screws.
 - 2. Hollow Masonry Units: Toggle bolts.
 - 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 - 4. Steelwork: Machine screws.
 - 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.
- E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.08 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
- C. Install with symmetrical bends or cast metal fittings.
- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- G. PVC Conduit:
 - 1. Bends 30 Degrees and Larger: Provide factory-made elbows.
 - 2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
 - 3. Use manufacturer's recommended method for forming smaller bends.
- H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 PVC CONDUIT

- A. Solvent Welding:
 - 1. Apply manufacturer recommended solvent to joints.
 - 2. Install in order that joint is watertight.
- B. Adapters:
 - 1. PVC to Metallic Fittings: PVC terminal type.
 - 2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.
- C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.10 PVC-COATED RIGID STEEL CONDUIT

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
- C. Provide PVC boot to cover exposed threading.

3.11 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.12 CABLE TRAYS

- A. Install in accordance with NEMA VE 1, Section Application Information.
- B. Install accessories as necessary for complete system.
- C. Install in order that joints are not made at support brackets.
- D. Install horizontal section support brackets between support point and quarter point of tray span.
- E. Provide ceiling trapeze for horizontal cable tray.
- F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.
- G. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.
- H. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.
- I. Install without exposed raw edges.
- J. Maintain 12-inch vertical separation between multi-tiered trays having a common support, and at crossover locations.
- K. Provide bonding jumper at each expansion joint and adjustable connection.
- L. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.13 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
- B. Nonmetallic, Cabinets, and Enclosures:
 1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
 2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
 - a. Install insulated bushing on ends of conduit where grounding is not required.
 - b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
 - c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
 - d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
 - e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized Conduit:
 - a. Provide one lock nut each on inside and outside of enclosure.
 - b. Install grounding bushing at source enclosure.
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchboard, Switchgear , and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.14 UNDERGROUND RACEWAYS

- A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
- B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.
- C. Make routing changes as necessary to avoid obstructions or conflicts.

- D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
- E. Union type fittings not permitted.
- F. Spacers:
 - 1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
 - 2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
- G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.
- H. Transition from Underground to Exposed: Rigid galvanized steel conduit.
- I. Installation with Other Piping Systems:
 - 1. Crossings: Maintain minimum 12-inch vertical separation.
 - 2. Parallel Runs: Maintain minimum 12-inch separation.
 - 3. Installation over valves or couplings not permitted.
- J. Concrete Encasement:
 - 1. As specified in Section 03 30 00, Cast-in-Place Concrete.
 - 2. Concrete Color: Red.
- K. Backfill:
 - 1. As specified in Section 31 23 23.15, Trench Backfill.
 - 2. Do not backfill until inspected by Contracting Officer.

3.15 UNDER SLAB RACEWAYS

- A. Make routing changes as necessary to avoid obstructions or conflicts.
- B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.
- C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.
- D. Raceway spacing, in a single layer or multiple layers:
 - 1. 3 inches clear between adjacent 2-inch or larger raceway.
 - 2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

- E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.
- F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.
- G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.
- H. Fittings:
 - 1. Union type fittings are not permitted.
 - 2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
 - 3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

- A. General:
 - 1. Install plumb and level.
 - 2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
 - 3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
 - 4. Install galvanized mounting hardware in industrial areas.
- B. Size:
 - 1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
 - a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
 - 2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
 - 3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. The Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Contracting Officer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
 - c. Do not straddle CMU block or other construction joints.
2. Light Switch:
 - a. 48 inches above floor.
 - b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
 - a. 15 inches above floor.
 - b. 6 inches above counter tops.
 - c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
 - a. General Interior Areas: 15 inches above floor.
 - b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
 - c. Industrial Areas, Workshops: 48 inches above floor.
 - d. Outdoor Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: Same as above inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on the Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.

2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
 3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
 4. Provide plaster rings where necessary.
 5. Boxes embedded in concrete or masonry need not be additionally supported.
- G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.
- H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.

2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Contracting Officer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 MANHOLES AND HANDHOLES

- A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.
- B. Do not install until final raceway grading has been determined.
- C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.
- D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.
- E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.19 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.
- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.20 IDENTIFICATION DEVICES

- A. Raceway Tags:
 - 1. Identify Raceway Schedule designation.
 - 2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
 - 3. Install tags at each terminus for concealed raceways.
 - 4. Provide noncorrosive wire for attachment.
- B. Warning Tape: Install approximately 18 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.
- C. Buried Raceway Marker:
 - 1. Install at grade to indicate direction of underground raceway.
 - 2. Install at bends and at intervals not exceeding 100 feet in straight runs.
 - 3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.21 PROTECTION OF INSTALLED WORK

- A. Protect products from effects of moisture, corrosion, and physical damage during construction.
- B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.
- D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

