

READ THIS FIRST

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

<https://www.portseattle.org/page/guide-specifications>.

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY AND NOTES TO DESIGNER

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetal conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Nonmetal wireways and auxiliary gutters.
 - 5. Surface raceways.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Handholes and boxes for exterior underground cabling.
- B. For all pullboxes 2'x2'x6" or larger, design engineer shall indicate size and locations on drawings. Pullboxes shall be sized to comply with NFPA 70.
- C. Terminal blocks shall be used for connecting and extending quantities of branch circuits in a single location.
 - 1. Where connecting feeder segments, compression splices shall be used instead of terminal blocks.

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D. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
 2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
 3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.
- E. Remove all abandoned conductors and raceways unless marked/labeled for future uses.
- F. Expansion joints: Where conduits pass a structural joint, designer shall identify the type of joint fittings required for each crossing. Designer shall identify the minimum type, lateral length, offset, vertical loops, and bend radius for each joint location. Joint designs shall be verified by WA licensed Structural Engineer.
- G. Liquid-carrying pipes are prohibited inside electrical and communication rooms without approval from F&I. Designers and contractors shall notify F&I during designs and before constructions if non-electrical/communication pipes are discovered in the design or as part of the existing conditions.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.
- D. RTRC: Fiberglass resin conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

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1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 3. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allied Tube & Conduit.
 2. O-Z/Gedney.
 3. Republic Conduit.
 4. Southwire Company.
 5. Thomas & Betts Corporation.
 6. Western Tube and Conduit Corporation.
 7. Wheatland Tube Company.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A. For use with 400 Hz systems only.
- E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch, minimum.
- F. EMT: Comply with ANSI C80.3 and UL 797 with steel compression type fittings.

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- G. FMC: Comply with UL 1; zinc-coated steel.
- H. LPMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- I. IMC: Intermediate metallic conduit (IMC) shall not be used.
- J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70 (NEC).
 - 2. Fittings for EMT:
 - a. Material: Compatible with conduit/tubing materials.
 - b. Type: Compression fittings only. SET-SCREW TYPE WILL NOT BE ALLOWED.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- K. Joint Compound for GRC: Approved, as defined in NFPA 70 (NEC), by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Thomas and Betts/Carlson CANTEX Inc.
 - 2. JM Eagle
 - 3. Southern Pipe
 - 4. Hubbell/Raco
- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- C. RNC: Schedule 40 or Schedule 80 EPC/PVC complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit type and material.

2.3 FIBERGLASS RESIN CONDUIT (RTRC) AND FITTINGS:

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Fiberglass conduit is not allowed unless approved by F&I for the specific application.

- A. Conduit: Reinforced Thermosetting Resin Conduit RTRC, Type AG (Above Ground) and XW (Exposed), and UL 2515 AG (Above Ground) or UL 2420 BG (Below Ground) listed.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Champion Fiberglass, Inc.
 - 2. Atkore
 - 3. Or Approved Equal.
- C. The conduit shall be free from defects including delamination, foreign inclusions, etc. It shall be nominally uniform in color, density, and physical properties. It shall be straight and the ends shall be cut square to the inside diameter. The resin system shall be epoxy anhydride-cured with no fillers. Glass shall be (E-type or E-CR).

Designer shall review the following: glass type selection should consider the following: low smoke vs no smoke and what temperature the fiberglass needs to handle.

- D. Joining Methods: Interference Joint – the conduit shall be supplied with an integrally wound tapered bell and machine tapered spigot which shall provide a concrete tight and watertight fit with a minimum pullout strength of 500 lbs. when tested in accordance with ASTM D 2105.
- E. Fittings: A complete line of fittings, adaptors, and elbows shall be available and shall be manufactured from the same materials and process as the conduit.

Designer shall review the following: fittings are recommended in lieu of factory offsets because factory offsets do not comply with minimal bending NEC bending radius for conduit.

- F. Sizes: Conduit and fittings shall be manufactured to IPS and ID trade sizes.
- G. Flammability: Conduit and fittings shall conform with UL 2515.
- H. Hangers and Supports: When supporting or hanging conduit on a wall or structure, the manufacturer supplying the conduit shall also supply the hangers and supports. Third party materials shall not be allowed.
- I. Thermal - Conduit and fittings shall conform with the following:
 - 1. Heat Deflection Temperature: 312° F per ASTM D 648
 - 2. Continuous Operating Temperature -40° to 250° F (-40° C to 110° C)
 - 3. Maximum Operating Temperature -60° to 260° F (-60° to 130° F)

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4. Coefficient of Thermal Expansion 1.25 x 10⁻⁵ in/in/F per ASTM D 696

- J. Impact Resistance: Conduit and fittings shall conform with minimum impact resistances as required by UL 2515.
- K. Compression Resistance: Conduit shall not decrease by more than 25% during testing set forth in UL 2515.
- L. Pipe Stiffness: Conduit stiffness shall meet or exceed the standards set forth in ASTM D2412.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70 (NEC).
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Provide all necessary features and components, where not indicated otherwise, as required to complete the wiring system and comply with NFPA 70 (NEC).
- F. Finish: Manufacturer's standard enamel finish and ANSI 61 gray color.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Allied Molded Products, Inc.
 - 2. Hoffman.
 - 3. Thomas and Betts/ Carlon Electrical Products.

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- B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- C. Description: PVC or Fiberglass polyester, extruded and fabricated to required size and shape. For fiberglass wireways, cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets. No hole or knockout. For PVC wireways, provide snap-on cover, mechanically coupled connections and plastic fasteners.
- D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- E. Provide all necessary features and components, where not indicated otherwise, as required to complete the wiring system and comply with NFPA 70 (NEC).

2.6 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
- C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Wiring Systems
 - b. Panduit Corp.
 - c. Wiremold / Legrand.

2.7 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 2. EGS/Appleton Electric.
 - 3. FSR Inc.
 - 4. Hoffman.
 - 5. Hubbell Incorporated.

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6. O-Z/Gedney.
 7. RACO; Hubbell.
 8. Thomas & Betts Corporation.
 9. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover and threaded hubs.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Metal Floor Boxes – for new concrete floors:
1. Material: Cast metal.
 2. Type: Fully adjustable.
 3. Shape: Rectangular.
 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb. shall be listed and marked for the maximum allowable weight.
- H. Sheet Metal Pull and Junction Boxes: NEMA OS 1, galvanized steel.
1. Less than 24 inches: 14 USS gauge
 2. 24 to 36 inches: 12 USS gauge.
 3. 36" or larger: 10 USS gauge.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- L. Gangable boxes are allowed.
- M. Hinged-Cover Enclosures – Comply with UL 50 and NEMA 250, Type 1 for interior applications and NEMA 3R, 4 or 4X for exterior applications or as indicated in contract documents.
1. For pullboxes and enclosures larger than 24" x 24":

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- a. Indoor: cover shall have continuous hinge with flush latch unless otherwise indicated. 110° swing opening.
 - b. Outdoor: cover shall have three-point hinge with flush latch.
 2. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel or with radio-frequency paint.
- N. Cabinets:
1. NEMA 250, Type 1, 3R, 4X or 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Panelboard enclosures: Panelboard enclosure criteria are address separately in Standard Section 262416.

2.8 TERMINAL BLOCKS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Technologies Company; Cooper Crouse-Hinds.
 2. EGS/Appleton Electric.
 3. FSR Inc.
 4. Hoffman.
 5. Hubbell Incorporated.
 6. O-Z/Gedney.
 7. RACO; Hubbell.
 8. Thomas & Betts Corporation.
 9. Wiremold / Legrand.
- B. Description:
1. Minimum 600-volt rating for 480-volt circuits
 2. Clamp or screw terminals sized for maximum conductor size
 3. Separate connection point for each conductor
 4. 10% spare terminal points
 5. Individual identification for each terminal block
 6. Phenolic block separators or barriers shall be used to isolate low-voltage and control terminations from analog and DC circuits.
- C. Quality Control: UL Listed and labeled as an assembly.

2.9 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70 (NEC), for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70 (NEC), by a qualified testing agency, and marked for intended location and application.
3. Comply with handhole requirements in Section 260543 Underground Ducts and Raceways for Electrical Systems.

B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of reinforced concrete or cast iron.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. NewBasis.
 - d. Nordic Fiberglass, Inc.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Quazite: Hubbell Power System, Inc.; Hubbell Power Systems.
2. Standard: Comply with SCTE 77.
3. Color of Frame and Cover: Gray.
4. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
7. Cover Legend: Molded lettering, "ELECTRIC."
8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
9. Handholes 18 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

PART 3 - INSTALLATION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: RMC (Aluminum RMC limited to 400Hz, grounding and special applications).
2. Concealed Conduit: PVC Schedule 40 is the standard for use in rebar-reinforced duct banks. Aluminum is excluded. Rigid steel conduit RMC or PVC Schedule 80 shall be used under roadways in non-reinforced duct banks.
3. Underground, Duct Bank Runs: RMC or PVC Schedule 40 conduit.

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4. Underground Conduit, single conduit runs: RNC. Outdoor lighting and branch circuits need not be placed in duct banks.
 5. Rooftop, Exposed: Rigid galvanized steel with bitumastic or PVC coating.
 6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 7. Boxes and Enclosures, Aboveground: NEMA 250, Type 4x.
 8. Galvanized electrical equipment exposed outdoors shall be painted with a minimum of 3 mil coating of paint to prevent zinc runoff to the stormwater system. Paint application by manufacturer is preferred to field painting for coverage and quality.
 9. Street Tunnel: For interior surfaces of the tunnel, RMC shall be used. RTRC Fiberglass is allowed for use for emergency circuits that require a 2-hr fire rating.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Aluminum RMC limited to 400Hz, grounding and special applications. Aluminum conduit, boxes or fittings shall not come in contact with concrete. Provide non-metallic sleeve where aluminum conduit passes through concrete structure.
 2. Exposed, Not Subject to Severe Physical Damage: EMT OR RMC identified for such use.
 3. Exposed and Subject to Severe Physical Damage: RMC. Raceway locations include the following:
 - a. Rigid steel conduit shall be used in traffic areas subject to damage up to 12'.
 4. Concealed in Ceilings and Interior Walls and Partitions: RMC OR EMT sizes ½" to 1-1/2" in non-traffic areas.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: RMC.
 7. Boxes and Enclosures: NEMA 250, Type 1 OR Type 12, except in damp or wet locations use NEMA Type 4, in corrosive locations use NEMA Type 4X stainless steel (316), or in hazardous location use NEMA Type 7.
 8. Elevator shafts, pits and machine rooms: RMC.
- C. Minimum Raceway Size:
1. ¾" trade size minimum for homeruns, outdoor applications and for conduit embedded in slabs.
 - a. Exception: 1/2-inch trade size shall be allowed for connecting to the last device on the circuit unless not permitted by code or the Authority Having Jurisdiction.
 2. For Communication system, 1-inch trade size minimum regardless of communication applications.
- D. Conduit larger than 2" trade size containing power conductors shall be RMC. However, EMT may be used for larger conduits containing communication wiring such as telephone, fire alarm and other low voltage systems.

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- E. Conduits, boxes and fittings shall be of the same material. Do not mix dissimilar metals due to galvanic reaction.
- F. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. NO SETSCREW TYPE FITTINGS ALLOWED. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealants recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. EMT: Use steel compression fittings only. NO SETSCREW TYPE FITTINGS ALLOWED. Comply with NEMA FB 2.10.
 - 4. Flexible Conduit: Use only external steel compression fittings listed for use with flexible conduit. NO SETSCREW TYPE FITTINGS ALLOWED. Comply with NEMA FB 2.20.
 - 5. Use Form 8 condolet bodies with cover and gasket for standard installation.
 - a. Condulets are not allowed for feeders. Use pullboxes or mogul type fittings for feeders.
 - b. Condulets must be correctly sized for the cable installed.
 - 6. Use Form 9 condolet bodies (aluminum) for 400Hz power.
- G. Clip type conduit fasteners are not allowed. All fasteners and clamps for conduit raceway support shall use mechanical bolted type hardware.
- H. All cable shall be installed in raceway, including plenum rated cable.
- I. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 ADDITIONAL INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 (NEC) limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Conduits shall not be supported from ducts, pipes or other systems foreign to the electrical installation. The entire electrical installation shall be kept independent from any other trade.
- C. Provide separate conduits for 480/277V circuits, 208/120V circuits and low voltage and controls cabling.
- D. Planning: the layout of all raceways shall be carefully planned by the contractor to ensure an installation which is neatly done and workmanlike. Any work showing improper care in planning will be ordered removed by the Port Resident Engineer, and shall be replaced in a neat and proper manner, without any additional cost to the Port.

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- E. Complete raceway installation before starting conductor installation. Mandrel conduits to verify integrity.
- F. Keep raceways at least 6 inches away from parallel runs of mechanical system piping. Maintain 12" minimum clearance between conduit and heat sources such as flues, steam pipes and heating appliances. Comply with NEC article 110.26. Install horizontal raceway runs above water and steam piping.
- G. Route exposed and concealed conduit parallel and perpendicular to building lines.
- H. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- I. Stub-Up Connections:
 - 1. Extend conduits a minimum of 6" through concrete floor slab for connection to freestanding equipment.
 - 2. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor.
 - 3. Arrange stub-ups so curved portions of bends are not visible above finished slab.
 - 4. Extend conductors to equipment with RMC. FMC may be used 6" above the floor.
- J. Conceal conduit and EMT within finished walls, ceilings, and floors unless approved otherwise by the Port Resident Engineer. Where existing wall surfaces are inaccessible, surface metal raceways may be provided where approved.
- K. Run concealed raceways with a minimum of bends, in the shortest practical distance considering type of building construction and obstructions. Install no more than the equivalent of four 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- L. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- M. Raceways may be surface mounted in unfinished equipment spaces such as mechanical rooms, electrical rooms, elevator machine rooms and attic spaces.
- N. In exposed areas around the terminal, raceways may be painted to match existing finishes. Raceways in exposed areas shall be painted to match surroundings.
- O. In conveyor areas should be considered a NEMA 12 installation because of the dusty environment. Conduit shall be RMC up to 10' AFF or within a 10' radius from conveyors.
- P. Support conduit within 12 inches of enclosures to which attached.

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- Q. Provide galvanized pipe sleeves and UL listed fire seal assembly for all concrete, masonry and fire rated penetrations.
- R. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcing rods at maximum 10-foot intervals.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Space raceways laterally to prevent voids in the concrete.
 4. Arrange raceways to keep a minimum of 3 inches of concrete cover in all directions.
 5. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 6. Change from PVC to schedule 80 PVC or RMC before rising above floor.
- S. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- T. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- U. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Align the raceway to enter squarely, and install the locknuts with dished part against the box. Install bushings on conduits.
- V. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- W. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- X. Cut conduit perpendicular to the length and ream it to remove burrs. Bends shall be carefully made to avoid injuring or flattening raceways. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. , Use temporary closures to prevent foreign matter or vermin from entering raceways.
- Y. Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2" size.
- Z. Install pull wires in empty raceways, except at sleeves and nipples. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- AA. Surface Raceways:

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1. Install surface raceway with a minimum 2-inch radius control at bend points.
 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
 3. Install a separate green ground conductor in raceways from junction box supplying the raceways to receptacle of fixture ground terminals.
- BB. Provide bushings on conduit stubs for control wiring.
- CC. Provide grounding connections for raceways, boxes and components and provide ground wire in all raceway as required by NFPA 70 (NEC) and Section 260526 – Grounding and Bonding for Electrical Systems. Conduit and metallic raceway may not be used as ground path.
- DD. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- EE. Expansion-Joints:
1. Provide Liquid tight flex conduit at expansion joints with sufficient slack to accommodate seismic movement, unless structural engineer requires expansion joint fitting. Wrap flex conduit with ground wire, connected to steel fittings at either end of flex.
- FF. Flexible Conduit: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Flexible conduit is also allowed at expansion joints. Any other use of flexible conduit must be approved by the Port Resident Engineer. Install a separate external ground connector across flexible connections. See section 260526 – Grounding and Bonding for Electrical Systems.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Separate external ground conductor is not required on flexible connections to floorboxes, poke-throughs and lighting fixture whips.
- GG. Outlet Box Installation:
1. Do not install boxes back-to-back in walls. Where it is not possible to offset boxes in a common wall, they may be mounted back to back with a minimum clearance of ¼ inch between boxes and with a sheet of high density fiberglass between the boxes.
 2. Where receptacle boxes and telecom devices are adjacent to one another, install receptacles not closer than 6" to and not greater than 12" from telecom device.
 3. Provide knockout closures for unused openings.
 4. Support boxes independently of conduit. Mount device boxes to wall studs using blocking material behind the box to insure that the box will remain square to the finished wall surface.

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5. Outlet and device boxes mounted in masonry walls shall be set at the bottom or top of a masonry unit course.
6. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes.
7. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
8. Provide recessed outlet boxes in finished areas.
9. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
10. Provide cast outlet boxes in exterior or wet location. Conduit shall not enter the top or sides of exterior wall outlet boxes. Conduit shall enter bottom only.
11. Mount outlets at the following heights above finished floor, unless otherwise noted on drawings:
 - a. Wall Switches: 48"
 - b. Convenience Outlets – Utility areas: 48"
 - c. Convenience Outlets – other areas: 18"
 - d. Above Counter Outlets: 48" or 6" above counter or backsplash
 - e. Telephone outlets : 18"
 - f. Wall phone outlets: 54"
 - g. Thermostats: 60"

HH. Pull and Junction Box Installation:

1. Locate so that covers are readily accessible at all times.
2. Provide pull boxes as required by NEC or as required to facilitate installation of work.
3. Mount and support independently of conduit. Mount boxes on building surfaces or support with trapeze hanger as described in Section 260529 – Hangers and Supports for Electrical Systems.
4. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

II. Enclosure and Cabinet Installation:

1. Install hinged cover enclosures and cabinets plumb and level. Support at each corner, minimum.

JJ. Terminal Blocks:

1. Minimum 600V-rating for 480V circuits
2. Clamp or screw terminals sized for maximum conductor size
3. Separate connection point for each conductor
4. 10% spare terminal points
5. Individual identification for each terminal block
6. Phenolic block separators or barriers shall be used to isolate low voltage and control termination from analog and DC circuits

KK. Floor Box Installation:

1. Set metal floor boxes level and flush with finished floor surface.

2. Use cast iron floor boxes for installations in slab on grade.

LL. Galvanized materials:

1. Galvanized electrical equipment installed exposed outdoors shall be painted with a minimum 3 mil coating of paint to prevent zinc runoff to the stormwater system. Paint application by manufacturer is preferred to field painting for coverage and quality.

- MM. Concrete encased conduits: All feeder and service conduits in ground under or exterior to the building shall be encased in minimum 3" thick concrete. Refer to Section 260543- "Underground Ducts and Raceways for Electrical Systems."

3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth. Underlay separated from soil with soil fabric.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes with bottom below frost line, minimum 12 inches below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. All conduit, sleeves, blockouts or openings around raceway and cable systems that penetrate building walls, floors and ceilings shall be sealed. Sealing materials shall be fire-rated, non-combustible type specifically designed for this type of installation and shall be approved by the AHJ. 3M brand or approved. See also Section 260544 – Sleeves and Seals for Electrical Raceways and Cabling

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- B. Install raceway sealing fittings at accessible locations according to NFPA 70 (NEC) and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70 (NEC) and manufacturer's written instructions.
- C. Raceways which pass through building roof, exterior walls of building above or below grade and floor slabs on grade shall be sealed on the interior side of the building using non-hardening sealing compound after all conductors have been installed in raceway. Sealing material shall be specifically designed for electrical wiring systems. Provide EDPM or neoprene pipe flashing boot for conduit passing through the building roof.
- D. Empty raceways in vaults shall be sealed with listed conduit sealant.
- E. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cables" and Section 078413 "Penetration Firestopping."

3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair coatings, finishes, and cabinets that are damaged or deteriorated at the time of Substantial Completion as recommended by manufacturer.
 - 2. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches and abrasions, from outlet fittings and devices.

END OF SECTION 260533