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		Date: 8/1/17
		Author: Office of Facilities
CC: Project Folder		

Change History


Date	Description of Change	Pages / Sections Modified	Change Approver Initials
8/1/17	Updated section on Installation Guidelines	9 – F. #17 & #18(added)	SO
6/15/16	Updated division section from 16130 to 26 05 33, removed references to other section numbers	-	mgl44
3/26/13	Amend item paragraph on acceptable fitting for EMT systems.	20 - 16130 E. #6 (Raceways and Boxes; Materials)	SO
3/26/13	Add next item defining data and security system runs.	25 - 16130 F #18 (Raceways and Boxes; Installation Guidelines)	SO

A. Summary


This section contains design criteria for conduit, metal raceways, multi-outlet assemblies, and various box systems for general electrical construction. For all underground services refer to Section: Underground Electrical Duct Bank.

B. System Design and Performance Requirements

1. Design metal conduit systems to maintain a continuous grounding path redundant to the grounding path provided by insulated grounding conductors.
2. Where necessary, field-paint conduit or raceway systems to match the color of existing surfaces upon which they are installed.
3. Provide dedicated conduit systems for the following:
 - Alternate service circuits
 - Emergency circuits
 - Fire alarm systems
 - Intrusion detection systems
 - Access control systems
 - Telecommunications systems
 - Public address systems
 - Audio/visual systems
4. Where wiring for environmental controls (including EM&C and isolated HVAC systems) must be run within conduits, provide a dedicated conduit system.

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5. Ensure that conduit or raceway routings shown on construction drawings follow actual proposed routings as closely as possible.
6. Give priority over conduit or raceway runs to runs of ductwork and piping that pitch or have similar elevation or location requirements.
7. As much as possible, conceal conduit that runs through finished areas. Design conduit routings that enable conduit to be fished through existing hollow walls and ceilings and routed through adjacent unfinished areas, such as basements, storage rooms, mechanical rooms, closets, and attics.
8. Avoid embedding conduit within concrete slabs.
9. Do not run exposed conduit on exterior walls.
10. Minimum conduit sizes:
 - a. Conduit sizes must be one trade size larger than the minimum sizes permitted by NEC calculations.
 - b. The minimum conduit size above grade must be 3/4 inches, except as noted in paragraph d.
 - c. Where a conduit connects to a single device, such as a wall switch, or to a system, 1/2-inch conduit is permitted if not filled to more than 20 percent of its cross-sectional area.
 - d. The minimum conduit size below grade is one inch, unless noted otherwise in the specification.
11. Use surface raceways only in finished areas where conduits cannot be concealed in existing construction. Types 3000 and 4000 SMR and multi-outlet assemblies may be used in laboratories and offices for flexibility in locating outlets, but must have devices or brackets to fasten them to the base.
12. If unavoidable, design surface raceway routings to blend in with existing architectural elements. Where possible, locate equipment in areas that will keep raceway runs unobtrusive.
13. Wherever possible, route exposed raceways along the tops of baseboards. Where raceways are routed along ceilings, run them tight along the junctions with wall surfaces. To keep raceway installations unobtrusive, rise and drop tight along corners, along door and window casings, or along beams, columns, or other existing features. Raceway runs directly across open wall or ceiling surfaces are not acceptable unless preferred routings are not feasible. Where raceways must be run across open surfaces, minimize extent of the run.


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14. Minimize the use of fittings and boxes.
15. Size boxes in accordance with NEC requirements for maximum capacity of the largest conduit entering the box, unless restricted by available installation space.
16. Locate boxes in finished areas above accessible ceilings. Where boxes are installed above inaccessible ceilings, locate them within six inches of the access panel.
17. Enclosures or boxes must be suitable for the locations in which they are installed.
 - a. Dry locations: NEMA 1 (general purpose).
 - b. Damp and wet locations: NEMA 3R (rain-tight).
 - c. Swimming pools and certain laboratories where corrosive fumes may be present: NEMA 4X (corrosion-resistant watertight and dust-tight).
 - d. Areas where gases and vapors create explosion hazards: NEMA 7 (Class I hazardous locations – air-break equipment).
 - e. Areas where combustible dust creates explosion hazards: NEMA 9 (Class II hazardous locations – air-break equipment).
 - f. Carpentry shops, machine shops, and similar locations: NEMA 12 (dust-tight and drip-tight) or NEMA 13 (oil-tight and dust-tight), as applicable.

C. Product Standards

Ensure that all products conform to the following standards:

- NEMA RN1, Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
- NEMA TC2, Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
- NEMA TC3, PVC Fittings for Use with Rigid PVC Conduit and Tubing
- UL 1, Flexible Metal Electrical Conduit
- UL 6, Rigid Metal Electrical Conduit
- UL 360, Liquid-Tight Flexible Steel Conduit, Electrical
- UL 514B, Fittings for Conduit and Outlet Boxes
- UL 651, Schedule 40 and 80 Rigid PVC Conduit
- UL 651A, Type EB and A Rigid PVC Conduit and HDPE Conduit
- UL 797, Electrical Metallic Tubing

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- UL 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
- UL 1242, Intermediate Metal Conduit
- UL 5, Surface Metal Electrical Raceways and Fittings
- UL 498, Electrical Attachment Plugs and Receptacles
- UL 50, Electrical Cabinets and Boxes
- NEMA OS1, Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
- UL 514A, Metallic Outlet Boxes, Electrical
- UL 870, Electrical Wireways, Auxiliary Gutters, and Associated Fittings

D. Manufacturers


1. Acceptable plastic-coated conduit manufacturers include:
 - Robroy
 - Carlon
2. Acceptable surface raceway systems manufacturers include:
 - Walker
 - Wiremold
 - Hubbell
3. Acceptable rigid galvanized conduit manufacturers include:
 - Allied Tube and Conduit
 - Republic Conduit
 - Western Tube and Conduit

E. Materials


1. Rigid galvanized metal conduit (RGC), electrical metallic tubing (EMT), and flexible metal conduit (FMC) must be galvanized steel, unless specific design conditions require alternate material.
2. All conduits, liquid-tight flexible metal conduits (LFMC) running into switchboards, boxes, panelboards, or ground bushings must be of interlocked steel construction with a PVC jacket. Specify conduit up to 1-1/4 inch trade size with an integral continuous grounding conductor. Use of Green Field connectors is not acceptable.

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3. Rigid nonmetallic conduit (RNMC) must be self-extinguishing, schedule 40 PVC, unless noted otherwise.
4. Fittings and supports must be compatible with conduit material. Die-cast zinc fittings are not acceptable.
5. Bushings must be of a metallic, insulating type, consisting of an insulating insert molded or locked onto the metallic body of the fitting.
 - a. Insulating material must be nylon or thermosetting phenolic. Bushings made entirely of metal or nonmetallic material are not permitted. However, metallic bushings may be used where EMT is terminated without entering a box (such as at telephone backboards).
 - b. Bushings on 1-1/4 inch trade size and larger conduits must be grounding-type.
6. Set screw fittings are not acceptable on EMT systems. Use split, clamp-type, threadless compression fittings.
7. All surface raceways must be steel, with a baked enamel finish, or aluminum. Nonmetallic raceways are not acceptable.
8. Designate raceway sizes and types on construction drawings as follows:
 - a. 500 SMR must be one-piece raceway with a 0.2 square-inch cross-sectional area (equivalent to Wiremold #V500 series) and an ivory finish, unless specific design conditions require an alternate finish.
 - b. 700 SMR must be one-piece raceway with a 0.25 square-inch cross-sectional area (equivalent to Wiremold #V700 series) and an ivory finish, unless specific design conditions require an alternate finish.
 - c. 2100 SMR must be a two-piece raceway with a 0.81 square-inch cross-sectional area, equivalent to Wiremold #2100 series.
 - d. 3000 SMR shall be a two-piece raceway with a 3.51 square-inch cross-sectional area, equivalent to Wiremold #3000 series.
 - e. 4000 SMR shall be a three-piece raceway consisting of a base, cover, and divider, with a 7.50 square-inch cross-sectional area, equivalent to Wiremold #4000 series.
9. Where receptacles are required in types 3000 and 4000 SMR, specify cover plates as described in section: Wiring Devices.


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10. Outlet and device boxes installed in dry locations must be galvanized steel with knockouts. Outlet and device boxes installed in damp or wet locations must be cast malleable iron.
11. Floor boxes must be fully adjustable, cast malleable iron for concrete floors and galvanized steel for wood floors.
12. Pull and junction boxes installed in dry locations must be sheet steel with an enamel finish. Pull and junction boxes installed in damp or wet locations must be cast aluminum with threaded hubs.
13. Wireways must be general-purpose, lay-in type, sheet steel with an enamel finish, and must include knockouts, fittings, and adapters, as necessary for a complete system.
14. Box covers must be suitable for use with boxes. Specify gaskets in damp and wet locations. Where necessary, specify plaster ring or extension covers. Where covers are required in finished areas, provide stainless steel covers with stainless steel fasteners, as described in section: [Wiring Devices](#). Specify brass covers with brass flanges where floor boxes are installed on carpeted floors. Specify screw covers for wireways, unless directed otherwise by the Yale University Project Manager.
15. NEMA 1 cabinets and enclosures must be sheet steel with an enamel finish. Where cabinets and enclosures are provided for housing controls, such as pushbuttons, pilot lights, and relays, covers must be mounted with a continuous hinge and close with a key-operated flush- or lever-type latch. Covers must also be equipped with an interior steel pocket for the storage of drawings and instructions. Provide an interior panel for mounting items such as terminal blocks, relays, and similar equipment. Provide accessory feet for free-standing units.
16. NEMA 3R enclosures must be sheet steel with an enamel finish.
17. NEMA 4X enclosures: stainless is preferred, but fiberglass-reinforced polyester is acceptable.
18. NEMA 7 and 9 enclosures must be cast aluminum. Covers must be of a threaded type or employ an alternate method to open and close quickly and easily. Covers with numerous bolts are not acceptable. Specify breathers and drains when enclosures are mounted in damp or wet locations.
19. NEMA 12 enclosures must be sheet steel with an enamel finish. Enclosures with knockouts are not acceptable.
20. Raceways used in plenums area shall be metallic construction only with no nonmetallic covering.


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F. Installation Guidelines

1. Unless otherwise noted, exposed raceways in finished interior locations must be surface metal raceway.
2. Specify EMT in all concealed or unfinished interior locations, with the following exceptions:
 - a. Specify FMC in dry locations to fish through inaccessible spaces (for example, within hollow walls or above hung ceilings not constructed of removable tiles or panels).
 - b. Specify FMC to connect to movable equipment, equipment installed in hung ceilings, or bus duct plugs in dry locations. Lengths of such flexible conduits must accommodate all anticipated ranges of movement. Lighting with ground conductor connections cannot exceed six feet.
 - c. Specify FMC to connect to vibrating equipment or equipment where sound isolation is required, including 25 KVA and larger transformers in dry locations.
 - d. Specify LFMC for the installation conditions described in paragraphs a, b, and c that occur in damp or wet locations, or where subject to contact with coolants, oils, corrosives, or other similar substances.
 - e. Specify rigid galvanized conduits for all other installation conditions in damp or wet locations.
 - f. Specify LFMC under raised floors.
 - g. Specify rigid galvanized conduits in hazardous locations. Where flexible connections are required in hazardous locations, specify fittings listed for such use.
 - h. In corrosive locations, specify PVC coated rigid galvanized conduit. Where conduit is also subject to physical damage, specify plastic-coated rigid galvanized conduits. In such locations, conduit fittings must also have plastic coatings.
 - i. Specify rigid galvanized conduits where conduit is subject to physical damage.
 - j. Specify rigid galvanized conduits where conduit is provided for systems operating above 600 volts.
 - k. Conduits installed within interior concrete slabs or below grade within building walls are considered to be installed in exterior locations.
 - l. All alternate services shall be run in a separate conduit system. If they are going through a common box with normal power system, a divider or barrier shall be installed.

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3. Specify rigid galvanized conduits in all exterior locations, with the following exceptions:
 - a. Conduits installed underground must be PVC schedule 80 or fiberglass. Where such conduits are encased by two inches or more of concrete, PVC schedule 40 or fiberglass, may be specified. The minimum earth cover must be 30 inches. Underground conduits serving circuits over 600 volts must be concrete-encased.
 - b. Concrete-encased conduits within buildings must be HDPE or PVC, schedule 40.
 - c. Conduits installed on rooftops must be sunlight-resistant PVC, schedule 80.
4. Conduit bodies used in two-inch trade size runs and larger must be mogul size.
5. Where empty conduits are to be run, specify a pull wire with identification tags at each end, indicating the purpose of the conduit and the location of other end. Plug the end of the conduit with the pull wire in place.
6. Where conduits are to be run underneath metal roof decking, specify spacers that provide a minimum one-inch gap between the conduit and the roof deck to avoid penetration of the conduit by roofing fasteners.
7. Where indicated by seismic criteria contained in Section: Electrical Supports and Seismic Restraints, specify the following:
 - a. Sleeves for conduits 2-1/2 inch trade size and larger.
 - b. Flexible connections where conduit crosses points designed to allow structural movement.
8. Maintain a conduit clearance of at least six inches from hot water, steam, and other high-temperature lines if cross conduit. If parallel to conduit than distance shall be greater than 12". Maintain a clearance of at least six inches between power conduits and instrument or communication conduits.
9. Where multiple circuits serve outlets located in a single length of raceway, connect the outlets in such a way that successive outlets are served by alternate circuits. Install types 3000 and 4000 SMR containing receptacles or telecommunications outlets and MOA 42 inches above the finished floor (measured to the center of the raceway), unless specific design conditions require a different mounting height. Do not, under any circumstances, install such raceways less than 15 inches or more than 54 inches above the finished floor (measured to the center of the raceway).

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10. Specify that surface metal raceways be painted in accordance with the requirements of Division 9, Finishes to match adjoining finishes.
11. Conduit bodies may be substituted for conductor pull boxes up to #2 AWG, except in telecommunications systems. Given sufficient conduit quantities and wire fill, outlet boxes 4 inches square by 1-1/2 inches deep or larger may be substituted for pull and junction boxes in runs of 1/2-inch and 3/4-inch conduit
12. The minimum depth of outlet and device boxes is 2-1/2 inches, except for boxes containing only splices, which may be 1-1/2 inches deep. The minimum depth of pull and junction boxes is twice the trade size of the largest conduit entering the box.
13. The installation of back-to-back recessed boxes in walls or partitions is not permitted.
14. Methods of securing raceways and boxes to structures are described in Section 16072: Electrical Supports and Seismic Restraints.
15. Cables, raceways, and equipment installed in the plenum shall be arranged and secured so as to allow the removal of panels and access to the equipment.
16. The connectors used with flexible metal conduit in plenums shall effectively close any opening in the connection.
17. Data and security wiring shall be run in EMT where exposed, including in mechanical and electrical rooms. In areas where these systems are run above drop ceilings, the wiring can be run in open tray with tray rated cables. Tray rated cables shall have an outer jacket of low smoke zero halogen type, not PVC.
18. All alternate service wiring in electrical and mechanical rooms shall be run in ridged galvanized conduit, without exception.

End of Section