

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16145

STANDARD WIRING SYSTEMS

06/04

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 GENERAL REQUIREMENTS
- 1.3 SUBMITTALS
- 1.4 FABRICATION AND ASSEMBLY DRAWINGS

PART 2 PRODUCTS

- 2.1 CONDUIT, RACEWAYS AND FITTINGS
 - 2.1.1 Intermediate Metal Conduit
 - 2.1.2 Rigid [Steel] [Aluminum] Conduit
 - 2.1.3 Rigid Plastic Conduit
 - 2.1.4 Electrical Metallic Tubing (EMT)
 - 2.1.5 Flexible Metallic Conduit
 - 2.1.6 Wireways and Auxiliary Gutters
 - 2.1.7 Surface Metal Raceways
 - 2.1.8 Surface Multiple-Outlet Assemblies
 - 2.1.9 Underfloor Raceways
- 2.2 WIRE AND CABLE
 - 2.2.1 Building Wire
 - 2.2.2 Lighting-Fixture Wiring
 - 2.2.3 Switchboard Wire
 - 2.2.4 Direct-Burial Cable
 - 2.2.5 Cable Tray Wire
 - 2.2.6 Standard Flexible Cable
 - 2.2.7 Splices and Connectors
- 2.3 SAFETY SWITCHES
- 2.4 FLUSH WIRING DEVICES
 - 2.4.1 Wall Switches
 - 2.4.2 Receptacles
 - 2.4.3 Clock Outlets
 - 2.4.4 Floor Outlets
 - 2.4.5 Weatherproof Outlets
 - 2.4.6 Device Plates
- 2.5 BOXES AND FITTINGS
 - 2.5.1 Sheet Metal Boxes and Outlets
 - 2.5.2 Cast-Metal Boxes
 - 2.5.3 Pull and Junction Boxes
 - 2.5.4 RFI-Shielded Enclosures

2.6 COMMUNICATION CABINETS

PART 3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation of Rigid Metal Conduit
- 3.1.2 Installation of Rigid PVC Conduit
- 3.1.3 Installation of EMT
- 3.1.4 Installation of Wireways and Auxiliary Gutters
- 3.1.5 Installation of Underfloor Raceways
- 3.1.6 Installation of Flexible Metallic Conduit

3.2 INSTALLATION OF WIRING

3.3 DIRECT-BURIAL CABLE

3.4 SAFETY SWITCHES

3.5 WIRING DEVICES

- 3.5.1 Wall Switches and Receptacles

- 3.5.2 Device Plates

3.6 BOXES AND FITTINGS

3.7 IDENTIFICATION PLATES

3.8 FIELD TESTING

-- End of Section Table of Contents --

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NASA-16145 (June 2004)
NASA
Superseding NASA-16145
(December 2003)

SECTION 16145

STANDARD WIRING SYSTEMS
06/04

NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers basic wiring materials and methods applicable to most types of interior electrical construction.

Drawings should indicate locations of service outlet fittings for power, telephone, and special services. Duct size should also be specified on drawings.

PART 1 GENERAL

1.1 REFERENCES

NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI C80.1 (1994; R 1995) Rigid Steel Conduit - Zinc Coated
- ANSI C80.3 (1994; R 1995) Electrical Metallic Tubing - Zinc-Coated
- ANSI C80.5 (1994: R 1995) Rigid Aluminum Conduit

ASTM INTERNATIONAL (ASTM)

- ASTM A 123/A 123M (2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM B 173 (2001a) Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

ASTM B 3 (2001) Standard Specification for Soft or Annealed Copper Wire

ASTM D 2301 (1999) Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 383 (1974; R 1992) Standard for Type Test Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electric Equipment (1000 Volts Maximum)

NEMA FB 1 (2001) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies

NEMA FB 11 (2000) Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type for Hazardous Locations

NEMA KS 1 (2001) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

NEMA RN 1 (1998) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 3 (2004) PVC Fittings for Use With Rigid PVC Conduit and Tubing

NEMA WC 5 (1992; R 1993) Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NEMA WD 1 (1999) General Requirements for Wiring Devices

NEMA WD 6 (2002) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1	(2004) UL Standard for Safety - Flexible Metal Conduit
UL 1242	(2003) UL Standard for Safety - Intermediate Metal Conduit
UL 1581	(2003) UL Standard for Safety - Reference Standard for Electrical Wires, Cables, and Flexible Cords
UL 20	(2002) General-Use Snap Switches
UL 486C	(2002) UL Standard for Safety Splicing Wire Connectors
UL 50	(2003) UL Standard for Safety - Enclosures for Electrical Equipment
UL 514A	(2004) UL Standard for Safety - Metallic Outlet Boxes
UL 514B	(2004) UL Standard for Safety Fittings for Conduit and Outlet Boxes
UL 6	(2003) UL Standard for Safety for Electrical Rigid Metal Conduit-Steel
UL 651	(2002) UL Standard for Safety Schedule 40 and 80 Rigid PVC Conduit
UL 797	(2003) UL Standard for Safety - Electrical Metallic Tubing
UL 83	(2004) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 854	(2002) UL Standard for Safety Service-Entrance Cables
UL 870	(2002) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 884	(1998) UL Standard for Safety Underfloor Raceways and Fittings

1.2 GENERAL REQUIREMENTS

NOTE: If Section 16003 GENERAL ELECTRICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

Section 16003 GENERAL ELECTRICAL PROVISIONS applies to work specified in this section.

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES in sufficient detail to show full compliance with the specification:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for the following items showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Conduit, Raceways and Fittings
Wire and Cable
Safety Switches
Flush Wiring Devices
Boxes and Fittings
Communication Cabinets

SD-02 Shop Drawings

The following types of drawings shall be submitted to check for contract conformity:

Fabrication Drawings
Assembly Drawings

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

Conduit, Raceways and Fittings
Wire and Cable
Safety Switches
Flush Wiring Devices
Boxes and Fittings
Communication Cabinets

SD-06 Test Reports

Test Reports shall be submitted for standard wiring systems in accordance with the paragraph entitled, "Field Testing," of this section.

SD-07 Certificates

Certificates of compliance shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Conduit, Raceways and Fittings
Wire and Cable
Safety Switches
Flush Wiring Devices
Boxes and Fittings
Communication Cabinets

1.4 FABRICATION AND ASSEMBLY DRAWINGS

Fabrication Drawings shall be submitted for the standard wiring systems consisting of fabrication and Assembly Drawings for all parts of the work in sufficient detail to enable the Government to check conformity with the requirements for the contract documents.

PART 2 PRODUCTS

2.1 CONDUIT, RACEWAYS AND FITTINGS

Conduit shall be 3/4 inch 20 millimeter diameter minimum, except where specifically shown smaller on the contract drawings, and except for exposed switch leg runs.

Conduit, connectors, and fittings shall be approved for the installation of electrical conductors.

2.1.1 Intermediate Metal Conduit

Intermediate metal conduit, including couplings, elbows, bends, and nipples, for use as a raceway for wire and cables in an electrical system shall conform to the requirements of UL 1242 as amended for thin or thick-wall types and shall also conform to NFPA 70. Interior and exterior surfaces of the conduit shall be protected with a metallic zinc coating.

2.1.2 Rigid [Steel] [Aluminum] Conduit

Rigid [steel] [aluminum] conduit, including couplings, elbows, bends, and nipples, shall conform to the requirements of UL 6 and [ANSI C80.1] [ANSI C80.5] [Steel fittings shall be galvanized by the hot-dip process. Where indicated, and in corrosive areas, rigid steel conduit shall be polyvinylchloride (PVC) coated and conform to NEMA RN 1, Type 20.]

Fittings for rigid [steel] [aluminum] conduit shall be threaded and shall conform to NEMA FB 1.

Gaskets shall be solid for fittings sized 1-1/2 inches 40 millimeter and less. Conduit fittings with blank covers shall have gaskets except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Covers shall have captive screws and shall be accessible after the work has been completed.

2.1.3 Rigid Plastic Conduit

PVC conduit shall be not lighter than Schedule 40. Rigid PVC shall be the slip-joint solvent-weld type, and fittings shall be unthreaded solid PVC. Conduit and fittings shall conform to UL 651 and NEMA TC 3.

2.1.4 Electrical Metallic Tubing (EMT)

EMT shall be rigid metallic conduit of the thinwall type in straight lengths, elbows, or bends and shall conform to ANSI C80.3 and the requirements of UL 797.

Couplings and connectors shall be hex-nut expansion-gland type, [zinc] [cadmium]-plated. Crimp, spring, or setscrew type fittings are not acceptable. Where EMT enters outlet boxes, cabinets, or other enclosures, connectors shall be the insulated-throat type, with a locknut. Fittings shall meet the requirements of NEMA FB 1.

2.1.5 Flexible Metallic Conduit

[Flexible metallic conduit shall meet the requirements of UL 1.]

[Liquidtight flexible metallic conduit shall be provided with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.]

[Fittings for flexible metallic conduit shall meet the requirements of UL 514B, Type I box connector, electrical, Type III coupling, electrical conduit, flexible steel, or Type IV adapter, electrical conduit.]

[Fittings for liquidtight flexible metallic conduit shall meet the requirements of UL 514B, Type I box connector, electrical, Class 3 liquidtight flexible metallic conduit connectors.]

2.1.6 Wireways and Auxiliary Gutters

Wireways and auxiliary gutters for use in exposed, dry locations shall be a prefabricated channel-shaped sheet metal trough with hinged or removable covers, associated fittings, and supports for housing, and protecting electrical wires and cables in accordance with UL 870.

Straight sections of trough, elbows, tees, crosses, closing plates, connectors, and hanging brackets shall be constructed from sheet steel of commercial quality not less than 16-gage 1.6 millimeter. Sheet metal component parts shall be cleaned, phosphatized, and coated with a corrosion-resistant gray paint.

Straight sections of wireways and auxiliary gutters shall be solid or have knockouts as indicated in both sides and bottom, 3 inches 75 millimeter on center.

Straight sections shall be not more than 5-feet 1500 millimeter long, [with covers held closed with screws.] [with hinged covers held closed with spring catches.]

2.1.7 Surface Metal Raceways

Surface metal raceways shall conform to the requirements of NFPA 70. Minimum size shall equal or exceed the capacity of 1/2 inch 15 millimeter

trade size conduit.

2.1.8 Surface Multiple-Outlet Assemblies

Surface multiple-outlet assemblies shall conform to the requirements of NFPA 70 and shall be provided with receptacles conforming to NEMA WD 1, NEMA FB 11 and NEMA WD 6, Figure 5-15R.

2.1.9 Underfloor Raceways

Underfloor raceways shall conform to UL 884 and NFPA 70.

2.2 WIRE AND CABLE

Insulated current-carrying wire and grounding conductors shall be copper and shall conform to NFPA 70 and UL 1581. Wire bundles with cable ties shall be secured to the enclosure with sheet-metal screws. Self-sticking adhesive attachments are not acceptable.

2.2.1 Building Wire

Building wire for use in conduits, raceways, and wireways shall be single-conductor, 600-volt, heat- and moisture-resistant insulated wire suitable for use in wet or dry locations.

Conductors AWG No. 10 2.5 millimeter diameter (AWG No. 10) and smaller shall be solid round copper wire. Conductors AWG No. 8 3.15 millimeter (AWG No. 8) and larger shall be standard concentric stranded copper wire. Conductors shall be not less than AWG No. 12 2.0 millimeter diameter (AWG No. 12), except that AWG No. 14 1.6 millimeter diameter (AWG No. 14) shall [be stranded copper wire and shall] be used for control wiring.

[Building wire shall be Type RHW with insulation of synthetic rubber, with a minimum temperature rating of 75 degrees C.]

[Building wire shall be Type THW with insulation of PVC, with a minimum temperature rating of 75 degrees C.]

[Building wire shall be Type THHN with insulation of PVC and nylon jacket, with a minimum temperature rating of 90 degrees C.]

[Building wire shall be Type THWN with insulation of PVC and nylon jacket, with a minimum temperature rating of 75 degrees C.]

2.2.2 Lighting-Fixture Wiring

[Lighting-fixture wire for outlet-box connection to incandescent-fixture lampholders shall be flexible seven-strand copper wire with insulation conforming to NFPA 70.]

[Lighting-fixture wire for use in fluorescent fixture wiring channels shall be flexible seven-strand or solid copper wire conforming to NFPA 70.]

2.2.3 Switchboard Wire

Switchboard wire used for instrument and control wiring on the back of switchboards and hinged-front instrument panels shall be single-conductor, 600-volt, flame- and heat-resistant insulated wire not smaller than AWG No. 14 1.6 millimeter diameter (AWG No. 14) with a minimum temperature rating

of 90 degrees C.

Conductors rigidly mounted on the back of switchboards and instrument panels shall be solid round, soft or annealed, copper wire conforming to ASTM B 3. Hinge connections shall be rope-lay-stranded copper conductors, Class H, conforming to ASTM B 173. All wires before stranding shall conform to ASTM B 3 for soft or annealed copper wire.

Switchboard wire shall be Type SIS with cross-linked thermosetting polyethylene insulation.

2.2.4 Direct-Burial Cable

Direct-burial cables for underground service entrance and underground feeders shall be single or multiple conductor as indicated, 600-volt, heat-and moisture-resistant Type [USE] [UF] with a minimum temperature rating of 75 degrees C.

Conductors AWG No. 8 3.15 millimeter (AWG No. 8) and smaller shall be solid, round, soft or annealed, copper wire. Conductors larger than AWG No. 8 3.15 millimeter (AWG No. 8) shall be standard concentric stranded copper wire. Conductors shall be not smaller than AWG No. 12 2.0 millimeter diameter (AWG No. 12). Cable insulation shall be cross-linked thermosetting polyethylene.

A vulcanized outer jacket of heavy-duty neoprene compound shall completely cover and closely conform to the surface of the underlying assembly in accordance with UL 854.

2.2.5 Cable Tray Wire

Power and control wire installed in cable trays shall be Type TC cable 600 volts, with current-carrying capacity as determined by NFPA 70. Cable shall also comply with UL 83 and IEEE Std 383.

2.2.6 Standard Flexible Cable

Flexible multiconductor cable shall conform to UL 1581 for control and power below 600 volts, noninstrumentation type. Cable shall contain one (green) grounding conductor and shall utilize a thermosetting or thermoplastic overall jacket in accordance with NEMA WC 5. A white conductor shall be included for the power neutral or grounded current-carrying conductor. Cable conductor insulation shall conform to NEMA WC 5.

2.2.7 Splices and Connectors

Splices in building wire AWG No. 8 3.15 millimeter (AWG No. 8) and smaller and multiple conductor cables shall be made with insulated Scotchlock, or equal, connectors or with indentor crimp-type connectors and compression tools to ensure a satisfactory mechanical and electrical joint.

Splices in building wire AWG No. 6 4.1 millimeter diameter (AWG No. 6) and larger and single-conductor cables shall be made with indentor crimp-type connectors and compression tools or with bolted clamp-type connectors to ensure a satisfactory mechanical and electrical joint.

Joints shall be wrapped with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor. Splices in

rubber-insulated neoprene-jacketed wire and cables shall be watertight.

Vinyl-plastic electrical insulating tape shall meet the requirements of ASTM D 2301. Where pressure-sensitive tape is used, the surface shall be cleaned free of dust, sand, or other foreign material and a primer recommended by the tape manufacturer shall be applied prior to taping.

Where indicated and for building wire AWG No. 8 3.15 millimeter (AWG No. 8) and larger, terminations shall utilize screw-set pressure terminal lugs.

Where indicated, building wire AWG No. 10 2.5 millimeter diameter (AWG No. 10) and smaller shall be terminated in pre-insulated crimp ring lugs on terminal blocks.

Solid wiring shall be terminated with terminal blocks specifically designed for solid wire. Crimp type shall not be used on solid wire for termination.

Stranded wire shall use [crimp] [spade] type lugs for termination on terminal blocks.

2.3 SAFETY SWITCHES

Switches shall comply with NEMA KS 1.

Safety switches shall be the heavy-duty type with voltage, current rating, number of poles, and fusing as indicated. Switch construction shall be such that, with the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device shall be coinproof and shall be so constructed that an external tool (screwdriver) must be used to open the cover. Provisions shall be made to lock the handle in the "OFF" position, but the switch handle shall not be capable of being locked in the ON position.

Switches shall be the quick-make, quick-break type. Terminal lugs shall be approved for use with copper conductors.

2.4 FLUSH WIRING DEVICES

2.4.1 Wall Switches

Snap switches installed for the control of incandescent, mercury, and fluorescent lighting fixtures shall be heavy-duty, general-purpose, noninterchangeable flush devices conforming to UL 20 and NEMA WD 1, as indicated.

Snap switches shall be the toggle type: [single-pole] [double-pole] [three-way] [four-way] two-position devices rated 20 amperes at 277 volts, 60 hertz, ac only, meeting the requirements of UL 20.

All snap switches shall be made by the same manufacturer.

Where two or more snap switches are to be installed at the same location, they shall be mounted in one-piece ganged switch boxes, with a gang cover plate.

[Snap switches shall be constructed so that two switches are able to fit into a single-gang switch box.]

Combination snap switch and single or duplex receptacles shall be mounted

in two-gang switch boxes, with a combination two-gang cover plate.

Combination snap switch and flush pilot light shall be interchangeable devices mounted in a one-gang switch box with a one-gang, two-opening cover plate. Pilot-light cover opening shall be fitted with a rectangular-shaped ruby-red plastic jewel in a metal frame.

2.4.2 Receptacles

Receptacles shall be 20-ampere, 125-volt ac, 2-pole, 3-wire, [single] [duplex] grounded, conforming to NEMA FB 11, NEMA WD 1 and to the 5-20R configuration in NEMA WD 6.

Bodies of 20-ampere receptacles shall be [phenolic] [nylon] compound supported by a mounting yoke having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Each receptacle shall be [side] [back] -wired with two screws per terminal, shall be provided with a third grounding pole, and shall be capable of receiving 2-wire, 3-pole parallel-blade caps. Third grounding pole shall be connected to a metal mounting yoke and shall be provided with a green-colored screw for grounding.

Power outlets for connection to [208] [480] volt, [single] [three] -phase, ac circuits shall consist of single locking receptacles in industrial cast-metal enclosures with cast-aluminum bodies, angle adapters, and receptacle housings with spring-loaded hinged lift covers, conforming to NEMA 250 for the indicated voltage and current rating. Springs and hinge pins shall be corrosion-resistant steel. Screws and spring covers shall be [chromium] [cadmium] -plated brass. [Rubber] [neoprene] gaskets shall provide a positive seal against the entrance of dust, lint, fibers, and oil or coolant seepage.

Locking receptacles shall conform to NEMA WD 6. One plug shall be furnished with each locking receptacle.

Receptacles shall meet the requirements for retention of plugs, overload, temperature, and assembly security in accordance with NEMA WD 1.

2.4.3 Clock Outlets

Clock outlets shall consist of a 15-ampere, 125-volt ac, 2-pole, 3-wire, single polarized receptacle in a standard approved flush-mounted outlet box with a matching wall plate and a clock-mounting hook. Outlets shall be recessed for plug caps that will allow surface-mounted clocks to hang flush with the finished wall. Wall plates shall be corrosion-resistant steel not less than [_____] [0.040] inch [1.02] millimeter thick, with beveled edge and brushed finish. Wall-plate mounting shall have an oval countersunk head finished to match the plate.

2.4.4 Floor Outlets

Convenience outlets installed in floors for connection to 120-volt ac single-phase circuits shall consist of single or duplex receptacles enclosed in floor boxes with cover plates especially approved for this purpose.

2.4.5 Weatherproof Outlets

Convenience outlets installed in outdoor damp or wet locations for

connection to 120-volt ac single-phase circuits shall consist of [single] [duplex] Ground Fault Circuit Isolation (GFCI) receptacles enclosed in weatherproof outlet boxes, with gasketed cast-aluminum plates and spring-loaded hinged lift covers. Springs and hinge pins shall be corrosion-resistant steel. Screws and spring covers shall be [chromium] [cadmium] -plated brass. Rubber or neoprene gaskets shall provide a positive seal against the weather.

2.4.6 Device Plates

Wall plates for flush snap switches and receptacles shall be the appropriate type and size and shall match the wiring devices for which they are intended. Dimensions for openings in wall plates shall be in accordance with NEMA WD 1.

[Wall plates for flush snap switches and receptacles shall be corrosion-resistant steel not less than 0.040 inch 1.02 millimeter thick, with beveled edges and a brushed satin finish. Mounting screws shall be corrosion-resistant steel with oval countersunk heads finished to match the plate.]

[Wall plates for flush snap switches and receptacles shall be molded ivory-colored phenolic or urea compounds, with rounded or beveled edges. Mounting screws shall have oval countersunk heads finished to match the plate.]

[Wall plates for flush snap switches and receptacles shall be molded brown-colored phenolic or urea compounds, with rounded or beveled edges. Mounting screws shall have oval countersunk heads finished to match the plate.]

[Wall plates for flush snap switches and receptacles shall be molded nylon. Mounting screws shall have oval countersunk heads finished to match the plate.]

2.5 BOXES AND FITTINGS

Boxes shall have sufficient volume to accommodate the number of conductors entering the box in accordance with the requirements of NFPA 70 and UL 514A. Boxes that are exposed to the weather or that are in normally wet locations shall be cast-metal with threaded hubs. Surface-mounted boxes on interior walls shall be cast-metal. Boxes in other areas shall be cadmium-plated or zinc-coated sheet metal.

2.5.1 Sheet Metal Boxes and Outlets

Outlet, switch, and junction boxes flush-mounted in walls or ceilings shall be [octagon] [square] [rectangular] -shaped gang boxes as appropriate, with extension rings and covers.

Ceiling outlet boxes, from which surface- and pendant-mounted lighting fixtures are supported, shall be not less than 4 inches 100 millimeter [octagonal] [square], with plaster rings 1-1/2 inches 40 millimeter deep and shall be capable of withstanding a vertical downward force of 200 pounds 890 newton for 5 minutes. All boxes in spaces above suspended ceilings shall be installed in accessible locations. Boxes in otherwise inaccessible locations shall be accessible from ceiling space access panels. Ceiling-mounted outlet boxes for lighting fixtures, fittings, and wiring devices shall be symmetrical, except as otherwise indicated, and

shall not interfere with the work of other trades.

Wall outlet boxes for [single] [two] -gang flush wiring devices shall be not less than 4 inches 100 millimeter square and 1-1/2 inches 40 millimeter deep. Wall outlet boxes for multiple-gang flush wiring devices shall be not less than 4-1/2 inches 115 millimeter wide and 2-1/2 inches 65 millimeter deep. Wall-mounted outlet boxes for lighting fixtures and flush devices shall be capable of withstanding a vertical downward force of 50 pounds 225 newton for a period of 5 minutes.

Boxes shall be formed from carbon-steel sheets of commercial quality, not less than 14-gage 1.9 millimeter. Boxes shall be one-piece construction, zinc- or cadmium-plated in accordance with UL 514A. Boxes and box extension rings shall be provided with knockouts. Boxes shall be designed for mounting flush wiring devices.

Exposed surface junction boxes shall be installed only in equipment rooms and other utility areas.

Surface-mounted boxes shall be outside flange type with a matching solid flat cover. Flush-mounted boxes in walls and floors shall be the outside flange type with a matching recessed solid walkway cover. Box bodies and covers shall be galvanized by the hot-dip process in accordance with ASTM A 123/A 123M, Class A.

2.5.2 Cast-Metal Boxes

Cast-metal pull and junction boxes having an internal unobstructed air space of more than 100 cubic inches 0.0016 cubic meter for connection to galvanized rigid steel conduits embedded in concrete or surface mounted shall be watertight rectangular boxes in accordance with UL 50 and NEMA FB 1.

Box bodies and covers shall be cast or malleable iron with a wall thickness not less than 1/8 inch 3 millimeter at every point, of greater thickness at reinforcing ribs and cover edges, and not less than 1/4 inch 6 millimeter in thickness at tapped holes for rigid steel conduit. Box bodies shall be provided with integral threaded conduit openings, as required. Mounting lugs shall be provided at the back or at the bottom corner of the box body. Boxes shall be provided with neoprene cover gaskets that will prevent the entrance of water into the enclosure. Covers shall be secured to box bodies with AWG No. 6 4.1 millimeter diameter (AWG No. 6) or larger [brass] [bronze] flathead screws.

2.5.3 Pull and Junction Boxes

Pull and junction boxes shall be fabricated from carbon steel and shall conform to UL 50. Box dimensions and conduit connections shall conform to NFPA 70.

Boxes shall be welded construction with flat removable covers fastened to the box with machine screws. Seams and joints at corners or back edges of the box shall be closed and reinforced with flanges formed of the same material from which the box is constructed or by other means such as continuous welding which provides a construction equivalent to integral flange construction.

Boxes intended for outdoor use shall be [cast] [hot-dipped galvanized] with threaded hubs and neoprene-gasketed covers.

Boxes intended for use in dry locations shall be sheet steel [hot-dipped] galvanized after fabrication conforming to UL 514A.

2.5.4 RFI-Shielded Enclosures

Radio-frequency interference (RFI)-shielded enclosures shall be provided where indicated to protect electrical equipment from RFI. Enclosures shall have continuously welded seams, exterior mounting and connection facilities, and sealing flanges for hinged doors or screw cover plates equipped with RFI seal gaskets made of woven plated steel mesh and neoprene.

2.6 COMMUNICATION CABINETS

Cabinets shall conform to UL 50.

Cabinets for signal systems shall have boxes constructed of code-gage, zinc-coated sheet steel with interior dimensions not less than those indicated. Each box shall be fitted with a hinged door with a flush catch. Doors shall provide the maximum sized openings to the box interiors. Boxes shall be provided with a 5/8 inch 16 millimeter plywood backboard having a two-coat insulating-varnish finish.

Cabinets for electrical controls with volume greater than 100 cubic inches 0.0016 cubic meter shall be hot-dip galvanized, aluminum, or code-gage sheet steel with corrosion-resistant baked enamel finish.

PART 3 EXECUTION

3.1 INSTALLATION

Power, lighting, control emergency light and power, and special-service systems and all related components shall be installed in accordance with NFPA 70, and shall be enclosed in separate conduit or separate conduit systems.

Any run of EMT, intermediate, or rigid conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall contain not more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting. Field bends shall be made in accordance with the manufacturer's recommendations, which normally require use of a one-size-larger bender than would be required for uncoated conduit. Installed conduit and fittings shall be free of dirt and trash and shall not be deformed or crushed. Empty conduit shall have a pull rope stalled.

Conduit shall be installed with a minimum of 3 inches 75 millimeter of free air space separation from mechanical piping.

Conduit in finished areas shall be installed concealed. Conduit passing through masonry or concrete walls shall be installed in sleeves.

Conduit shall be securely clamped and supported at least every 10 feet 3000 millimeter vertically and 8 feet 2400 millimeter horizontally. Galvanized pipe straps shall be fastened to structure with bolts, screws, and anchors. Wooden masonry plugs shall not be used.

Conduit and boxes shall not be supported from T-bar ceiling wires.

All recessed outlet boxes in non-combustible walls or ceilings shall be

installed flush, such that the outlet box is set back less than 1/16 inch 2 millimeter or protrudes less than 1/16 inch 2 millimeter from the face of the ceiling or wall.

Conduit connections to boxes and fittings shall be supported not more than 36 inches 900 millimeter from the connection point. Conduit bends shall be supported not more than 36 inches 900 millimeter from each change in direction. Conduit shall be installed in neat symmetrical lines parallel to the centerlines of the building construction and the building outline. Multiple runs shall be parallel and grouped whenever possible on common supports.

Conduit and raceway runs in or under concrete, in damp, corrosive, or outdoor locations, in hazardous areas, where subject to mechanical damage, or intended for conductors rated over 600 volts, shall be rigid steel conduit. Conduit joints in corrosive areas shall be painted with [corrosion] [acid]-inhibiting compounds.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 5 feet 1470 millimeter or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

Ends of conduit extending from the interior to the exterior of the building and portions of interior conduit exposed to widely varying temperatures shall be sealed to prevent the passage of air within the conduit. Conduit shall be sloped to drain and shall be provided with drainage fittings at the lower end of the run. Curved portion of conduit bends shall not be visible above the finished floor. Underground service entrance and feeder conduit entering or leaving the building above the ground floor shall be terminated in a pull box.

Expansion fittings with flexible ground strap shall be provided in conduit runs crossing building expansion joints.

Underground portions of conduit runs shall be painted with bitumastic or shall be provided with a factory-applied coating of PVC not less than 0.20 inch 5 millimeter thick. Underground conduit encased in concrete does not require a protective coating of PVC. When the factory-applied coating is chosen by the Contractor, any nicks, cuts, or other abrasions shall be wrapped with a single layer of 0.010 inch 0.254 millimeter thick pressure-sensitive PVC tape, half-lapped to obtain a minimum thickness of 0.20 inch 5 millimeter. Couplings shall be wrapped with pressure-sensitive tape, as described above, over the coupling and for 2 inches 50 millimeter on each side of the coupling. When precoated couplings designed for the purpose are used, taping may be omitted provided the manufacturer's adhesive is used between the coating on the coupling and the coating on the conduit. Depth of buried conduit shall be in accordance with NFPA 70 or as indicated on the contract drawings.

Exposed ends of conduit without conductors shall be sealed with watertight caps or plugs.

Bushings shall be provided on the open ends of conduit containing conductors. Insulated bushings shall be provided for conduits containing conductors AWG No. 4 5.2 millimeter diameter (AWG No. 4) or larger with an insulating ring an integral part of the bushing.

Flexible metallic conduit shall be used to connect recessed fixtures from

outlet boxes in ceilings, metallic transformers, and other approved assemblies. Sections of flexible steel conduit shall be not more than 6 feet 1800 millimeter long and shall be installed only in exposed or accessible locations. Interior surfaces of conduit shall be free from burrs and sharp edges which might cause abrasion of wire and cable coverings. Ends of flexible steel conduit shall be provided with grounding bushings and approved fittings.

Bonding wires shall be used in flexible conduit for all circuits. Flexible conduit shall not be considered a ground conductor.

Liquidtight flexible metallic conduits shall be used in wet and oily locations and to complete the connection to motor-driven equipment.

Electrical connections to vibration-isolated equipment shall be made with flexible metallic conduit in a manner that will not impair the function of the equipment.

Wire or cable shall not be installed in conduit until the conduit system is completed; the inner surfaces of conduit shall be clean and dry.

A [nylon] [polypropylene] pull rope with a tensile strength not less than 130 pounds 580 newton shall be installed in empty conduit.

3.1.1 Installation of Rigid Metal Conduit

Ends of conduit shall be cut square, reamed and threaded, and joints shall be brought butt-to-butt in the couplings. Joints shall be mechanically tight. Conduit shall be protected against damage and the entrance of water or foreign material during construction.

Ninety-degree bends of conduit with a diameter larger than 1 inch 25 millimeter shall be made with factory-made elbows. Conduit elbows larger than 2-1/2 inches 65 millimeter shall be long radius. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Changes in directions of runs shall be made with symmetrical bends or cast-metal fittings.

At connections to sheet metal enclosures and boxes, a sufficient number of threads shall project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknut shall be pulled up sufficiently tight to draw the bushing into firm electrical contact with the box. Conduit shall be fastened to sheet metal boxes and cabinets with two locknuts where required by NFPA 70 where insulating bushings are used, where bushings cannot be brought into firm contact with the box, and where indicated.

Conduit joints shall be made with tapered threads set firmly. Each length of conduit cut in the field shall be reamed before installation. Where conduit is threaded in the field, each threaded end shall consist of at least five full threads. Corrosion-inhibitive compound shall be used on conduit threads in exterior areas.

Conduit stubbed-up through concrete floors for connections to free-standing equipment except motor-control centers, cubicles, and other such items of equipment shall be provided with a flush coupling if the floor slab is of sufficient thickness; if not, a floor box shall be provided and set flush with the finished floor. Conduits installed for future use shall be terminated with a coupling and plug set flush with the floor.

3.1.2 Installation of Rigid PVC Conduit

Rigid PVC conduit for underground work shall be encased in a concrete envelope or direct buried as specified for underground ducts. Where suitable protection is provided, PVC can be run exposed particularly in high corrosion areas.

A continuous, bare, soft-drawn copper ground wire shall be run in conduit with conductors and shall be solidly connected to ground at each end. Ground wires shall be sized in accordance with NFPA 70.

Rigid PVC conduit shall be stored on a flat surface and shall be protected from the direct rays of the sun.

3.1.3 Installation of EMT

EMT shall be cut square and reamed to remove burrs and rough surfaces.

Field-made bends and offsets shall be avoided where possible but, where necessary, shall be made with an approved hickey or conduit-bending machine. Changes in direction of runs shall be made with symmetrical bends or approved metal fittings.

3.1.4 Installation of Wireways and Auxiliary Gutters

Straight sections and fittings shall be bolted together to provide a rigid mechanical connection and electrical continuity. Dead ends of wireways and auxiliary gutters shall be closed. Unused conduit openings shall be plugged.

Wireways for overhead distribution and control circuits shall be supported at maximum 5-foot 1500 millimeter intervals.

Auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure shall not contain switches, overcurrent devices, appliances, or apparatus and shall be not more than 30 feet 9000 millimeter long.

3.1.5 Installation of Underfloor Raceways

Ducts shall be installed using preset inserts [_____] inches millimeter on center. Inserts shall be 1/8 inch 3 millimeter below the surface of the floor.

Blank duct may be used in lieu of insert duct in permanent corridors and passages.

3.1.6 Installation of Flexible Metallic Conduit

Flexible metallic conduit shall be installed only in exposed, accessible locations in accordance with NFPA 70. A grounding green conductor shall be installed in all runs. Connections to motors and vibrating equipment shall be made with flexible metallic conduit.

3.2 INSTALLATION OF WIRING

Raceways shall be completely installed, with interiors protected from the weather, before proceeding with the installation of wires and cables.

Conductors of special-service systems and emergency light and power systems shall not occupy the same enclosure with light and power conductors or the same enclosure with each other. Conductors shall be continuous with splices and connections made in outlet, junction, or pull boxes only. All control wiring shall be continuous between components and/or terminal boards.

Phase conductors and the neutral conductor of each branch or feeder circuit shall be contained in a single enclosure or paralleled in separate enclosures to avoid overheating the raceway by electromagnetic induction. Conductors and conduit in parallel shall be the same length and size, shall have conductors of the same type of insulation, shall be terminated at both ends in a manner to ensure equal division of the total current among conductors, and shall have a separate neutral conductor in each conduit.

Sharing of a common neutral between single phase circuits, connected to different phases, shall not be permitted.

Conductors installed in heavy-wall rigid steel conduit and EMT shall have allowable current-carrying capacity and ampere ratings in accordance with NFPA 70. Larger-sized conductors shall be used to compensate for derating factors when more than three current-carrying conductors are installed in raceways and when conductors are installed in wet locations.

Conductors 600 volts and below shall be color coded in accordance with the following:

<u>CONDUCTOR</u>	120/208 <u>COLOR</u>	480/277 <u>COLOR</u>
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	White/Gray
Equipment Grounds	Green	Green

Conductors up to and including AWG No. 2 6.5 millimeter diameter (AWG No. 2) shall be manufactured with colored insulating materials. Conductors larger than AWG No. 2 6.5 millimeter diameter (AWG No. 2) shall have ends identified with colored plastic tape in outlet, pull, or junction boxes. Control circuit conductors shall be identified at each connection point.

Connectors and splices shall conform to UL 486C and shall be made in approved enclosures utilizing solderless pressure connectors and adequate insulation with vinyl-plastic electrical insulating tape. Conductors and materials used in a splice, tap, or connection shall be thoroughly cleaned prior to makeup to ensure good electrical and mechanical connections. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Terminal and conductor identification shall match that shown on approved shop drawings. Hand lettering or marking is not acceptable. Control-circuit terminals of equipment shall be properly identified by color-coded insulated conductors, number-coded plastic self-sticking printed markers, or permanently attached metal-foil markers. Cable fittings shall conform to UL 514B; insulating tape shall conform to ASTM D 2301.

Where several feeders pass through a common pullbox, the feeders shall be tagged to clearly indicate the electrical characteristics, circuit number, and panel designation.

Grounding shall be provided in accordance with NFPA 70. Noncurrent-carrying parts of electrical equipment shall be bonded and grounded together.

3.3 DIRECT-BURIAL CABLE

Direct-burial cable shall comply with the following requirements:

Minimum width and depth of trenches shall be as indicated on the drawings.

Minimum depth of cable rated 600 volts and under shall be 24 inches 600 millimeter.

Minimum depth of cable rated 600 volts and under in conduit shall be 18 inches 460 millimeter.

Direct-burial cable shall be placed in the trench on top of a 3 to 4 inch 75 to 100 millimeter layer of screened sand or fill dirt.

A layer of screened sand or fill dirt 6 to 8 inches 150 to 200 millimeter thick shall be laid on top of the cable and tamped tightly.

A bright yellow PVC ribbon, minimum 2 inches 50 millimeter wide, continuously marked CAUTION -- ELECTRICAL SERVICE BELOW shall be placed on the trench approximately 8 inches 200 millimeter below surface ground level and run continuously parallel with and above the cable.

Where trenches cut roadways or other existing paved areas used for vehicular traffic, the existing pavement shall be sawcut prior to excavation, the pavement removed, and the trench excavated to the required depth. After the cable or conduit has been laid, the trench shall be backfilled and compacted in accordance with Section 02312 EXCAVATION, BACKFILLING, AND COMPACTING FOR UTILITIES. Backfill shall be free of roots, trash, debris, and stones.

3.4 SAFETY SWITCHES

Switches shall be securely fastened to the supporting structure or wall utilizing a minimum of four 1/4 inch 6 millimeter bolts. Sheet metal screws and small machine screws shall not be used for mounting. Switches shall not be mounted in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height shall be 5 feet 1500 millimeter above floor level, when possible.

3.5 WIRING DEVICES

3.5.1 Wall Switches and Receptacles

Wall switches and receptacles shall be so installed that when device plates are applied, the plates will be aligned vertically to within 1/16 inch 2 millimeter.

Ground terminal of each flush-mounted receptacle shall be bonded to the outlet box with an approved green bonding jumper.

3.5.2 Device Plates

Device plates for switches that are not within sight of the loads controlled shall be suitably engraved with a description of the loads.

Device plates and receptacle cover plates for receptacles other than 15-ampere, 125-volt, single-phase, duplex, convenience outlets shall be suitably engraved, showing the circuit number, voltage, frequency, phasing, and amperage available at the receptacle; for example: RP1-12, 208 VOLTS, 60 HERTZ, 3-PHASE, 30 AMPERES. If engraving is not practical, an engraved laminated phenolic identification plate may be applied.

Device plates shall be identified on the inside by circuit number and panelboard.

3.6 BOXES AND FITTINGS

Pullboxes shall be furnished and installed where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than 100 feet 30 meter or with more than three right-angle bends shall have a pullbox installed at a convenient intermediate location.

Boxes and enclosures shall be securely mounted to the building structure with supporting facilities independent of the conduit entering or leaving the boxes.

Bonding jumpers shall be used around concentric or eccentric knockouts.

Approximate mounting height of wall-mounted outlet and switch boxes, measured between the bottom of the box and the finished floor, shall be as follows:

<u>LOCATION</u>	<u>MOUNTING HEIGHT</u>
Receptacles in offices	18 inches 460 millimeter
Receptacles in corridors	18 inches 1220 millimeter
Receptacles for clocks	96 inches 2440 millimeter
Switches for light control	48 inches 1220 millimeter
Thermostats	66 inches 1675 millimeter

3.7 IDENTIFICATION PLATES

Red identification plates reading CAUTION: 480/277 VOLTS shall be provided in switch and outlet boxes containing 277- or 480-volt circuits. An identification plate marked DANGER: 480 VOLTS shall be provided on the outside of 480-volt enclosures. Identification plate shall use white lettering on a red laminated plastic.

Any equipment with externally powered wiring shall be marked with a laminated plaster nameplate having 3/16 inch 5 millimeter high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

3.8 FIELD TESTING

Test reports shall be submitted in accordance with referenced standards in this section.

After completion of the installation and splicing, and prior to energizing the conductors, wire and cable shall be given continuity and insulation tests as herein specified before the conductors are energized.

Necessary test equipment, labor, and personnel shall be provided by the Contractor to perform the tests, as herein specified. Continuity tests shall be conducted using a dc device with bell or buzzer.

Wire and cable in each voltage classification shall be completely isolated from all extraneous electrical connections at cable terminations and joints. Substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices shall be used to isolate the circuits under test.

Insulation tests on circuits rated 480-volts and less shall be conducted using a 500- or 1,000-volt insulation-resistance test set. Readings shall be taken every minute until three equal and consecutive readings are obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

Insulation tests on circuits rated 240 volts or less, with conductor sizes 2 AWG and larger, shall be conducted using a 500- or 1,000-volt insulation-resistance test set. Readings shall be taken after 1 minute and until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

Phase-rotation tests shall be conducted on all three-phase circuits using a phase-rotation indicating instrument. Phase rotation of electrical connections to connected equipment shall be clockwise, facing the source.

Final acceptance will depend upon the successful performance of wire and cable under test. No conductor shall be energized until the installation is approved.

-- End of Section --