
USACE / NAVFAC / AFCEA / NASA UFGS-26 27 26.00 40 (October 2006)

Preparing Activity: NASA Superseding
 UFGS-26 27 26.00 40 (June 2006)
 NASA-16145S (December 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 9 October 2006

Latest change indicated by CHG tags

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WIRING DEVICES 10/06

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.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in

this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

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; R 2004) Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape |

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- | | |
|--------------|---|
| IEEE Std 383 | (2003) Standard for Qualifying Class 1E Electric Cables and, Field Splices for Nuclear Power Generating Stations 2004 |
|--------------|---|

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- | | |
|------------|---|
| NEMA 250 | (2003) Enclosures for Electrical Equipment (1000 Volts Maximum) |
| NEMA C80.1 | (2005) Standard for Electrical Rigid Steel Conduit (ERSC) |
| NEMA C80.3 | (2005) Standard for Electrical Metallic Tubing (EMT) |
| NEMA C80.5 | (2005) Standard for Electrical Rigid Aluminum Conduit (ERAC) |
| NEMA FB 1 | (2003) Standard for Fittings, Cast Metal |

	Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FB 11	(2000) Standard for Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations
NEMA KS 1	(2001) Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
NEMA RN 1	(1998) Standard for Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 3	(2004) Standard for PVC Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WC 70	(1999 Errata 2001) Standard for Non-Shielded Power Cable 2000 V or Less
NEMA WC 71	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 74	(2000) Standard for 5-46 kV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy
NEMA WD 1	(1999) Standard for General Requirements for Wiring Devices
NEMA WD 6	(2002) Standard for Wiring Devices - Dimensional Requirements
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	(2005) National Electrical Code
UNDERWRITERS LABORATORIES (UL)	
UL 1	(2004; Rev 2) Standard for Flexible Metal Conduit
UL 1242	(2003; R 2005) Standard for Electrical Intermediate Metal Conduit - Steel
UL 1581	(2003; R 2005) Reference Standard for Electrical Wires, Cables, and Flexible Cords
UL 20	(2004) Standard for General-Use Snap Switches
UL 486C	(2004) Standard for Splicing Wire Connectors
UL 50	(2003; R 2005) Standard for Enclosures for Electrical Equipment

UL 514A	(2005) Standard for Metallic Outlet Boxes
UL 514B	(2004; R 2005) Standard for Fittings for Conduit and Outlet Boxes
UL 6	(2004e13) Standard for Electrical Rigid Metal Conduit-Steel
UL 651	(2005e7) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 797	(2000e8) Standard for Electrical Metallic Tubing
UL 83	(2005e13) Standard for Thermoplastic-Insulated Wires and Cables
UL 854	(2004; R 2005e11) Standard for Service-Entrance Cables
UL 870	(2003e7) Standard for Wireways, Auxiliary Gutters, and Associated Fittings
UL 884	(2005e11) Standard for Underfloor Raceways and Fittings

1.2 GENERAL REQUIREMENTS

NOTE: If Section 26 00 00.00 40 ELECTRICAL is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

Section 26 00 00.00 40 ELECTRICAL applies to work specified in this section.

1.3 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 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.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G"

designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit Material, Equipment, and Fixture Lists 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

Submit the following types of drawings to check for contract conformity:

Fabrication Drawings
Assembly Drawings

SD-03 Product Data

Submit manufacturer's catalog data 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

Submit [Test Reports](#) for standard wiring systems in accordance with the paragraph entitled, "Field Testing," of this section. Minimum

test reports required are as follows:

Insulation-Resistance Test
Continuity Test
Phase-Rotation Tests

SD-07 Certificates

Submit Certificates of Compliance 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

Submit [Fabrication Drawings](#) 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

Provide conduit with [20 millimeter 3/4 inch](#) diameter minimum, except where specifically shown smaller on the contract drawings, and except for exposed switch leg runs.

Conduit, connectors, and fittings must 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 must conform to the requirements of [UL 1242](#) as amended for thin or thick-wall types and must also conform to [NFPA 70](#). Interior and exterior surfaces of the conduit must be protected with a metallic zinc coating.

2.1.2 Rigid [Steel] [Aluminum] Conduit

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

Fittings for rigid [steel] [aluminum] conduit must be threaded and must conform to [NEMA FB 1](#).

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

required.

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

2.1.1.3 Rigid Plastic Conduit

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

2.1.1.4 Electrical Metallic Tubing (EMT)

EMT must be rigid metallic conduit of the thinwall type in straight lengths, elbows, or bends and must conform to [NEMA C80.3](#) and the requirements of [UL 797](#).

Couplings and connectors must 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 must be the insulated-throat type, with a locknut. Fittings must meet the requirements of [NEMA FB 1](#).

2.1.1.5 Flexible Metallic Conduit

[Flexible metallic conduit must meet the requirements of [UL 1](#).]

[Liquidtight flexible metallic conduit must 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 must 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 must meet the requirements of [UL 514B](#), Type I box connector, electrical, Class 3 liquidtight flexible metallic conduit connectors.]

2.1.1.6 Wireways and Auxiliary Gutters

Wireways and auxiliary gutters for use in exposed, dry locations must 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 must be constructed from sheet steel of commercial quality not less than [1.6 millimeter 16-gage](#). Sheet metal component parts must be cleaned, phosphatized, and coated with a corrosion-resistant gray paint.

Straight sections of wireways and auxiliary gutters must be solid or have knockouts as indicated in both sides and bottom, [75 millimeter 3 inches](#) on center.

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

2.1.7 Surface Metal Raceways

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

2.1.8 Surface Multiple-Outlet Assemblies

Surface multiple-outlet assemblies must conform to the requirements of NFPA 70 and must 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 must conform to UL 884 and NFPA 70.

2.2 WIRE AND CABLE

Insulated current-carrying wire and grounding conductors must be copper and must conform to NFPA 70 and UL 1581. Wire bundles with cable ties must 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 must be single-conductor, 600-volt, heat- and moisture-resistant insulated wire suitable for use in wet or dry locations.

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

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

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

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

[Building wire must 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 must be flexible seven-strand copper wire with insulation conforming to NFPA 70.]

[Lighting-fixture wire for use in fluorescent fixture wiring channels must 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 must be single-conductor, 600-volt, flame- and heat-resistant insulated wire not smaller than 1.6 millimeter diameter (AWG No. 14) AWG No. 14 with a minimum temperature rating of 90 degrees C.

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

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

A vulcanized outer jacket of heavy-duty neoprene compound must 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 must be Type TC cable 600 volts, with current-carrying capacity as determined by NFPA 70. Cable must also comply with UL 83 and IEEE Std 383.

2.2.6 Standard Flexible Cable

Flexible multiconductor cable must conform to UL 1581 for control and power below 600 volts, non-instrumentation type. Cable must contain one (green) grounding conductor and must utilize a thermosetting or thermoplastic overall jacket in accordance with NEMA WC 70, NEMA WC 71 and NEMA WC 74. A white conductor must be included for the power neutral or grounded current-carrying conductor. Cable conductor insulation must conform to NEMA WC 70, NEMA WC 71 and NEMA WC 74.

2.2.7 Splices and Connectors

Splices in building wire 3.15 millimeter (AWG No. 8) AWG No. 8 and smaller and multiple conductor cables must 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 4.1 millimeter diameter (AWG No. 6) AWG No. 6 and

larger and single-conductor cables must 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 must 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 must be watertight.

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

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

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

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

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

2.3 SAFETY SWITCHES

Switches must comply with [NEMA KS 1](#).

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

Switches must be the quick-make, quick-break type. Terminal lugs must 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 must be heavy-duty, general-purpose, noninterchangeable flush devices conforming to [UL 20](#) and [NEMA WD 1](#), as indicated.

Snap switches must 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 must be made by the same manufacturer.

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

plate.

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

Combination snap switch and single or duplex receptacles must be mounted in two-gang switch boxes, with a combination two-gang cover plate.

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

2.4.2 Receptacles

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

Power outlets for connection to [208] [480] volt, [single] [three] -phase, ac circuits must 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 must be corrosion-resistant steel. Screws and spring covers must be [chromium] [cadmium] -plated brass. [Rubber] [neoprene] gaskets must provide a positive seal against the entrance of dust, lint, fibers, and oil or coolant seepage.

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

Receptacles must 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 must 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 must be recessed for plug caps that will allow surface-mounted clocks to hang flush with the finished wall. Wall plates must be corrosion-resistant steel not less than [_____] [1.02] millimeter [0.040] inch thick, with beveled edge and brushed finish. Wall-plate mounting must 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 must 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 must 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 must be corrosion-resistant steel. Screws and spring covers must be [chromium] [cadmium] -plated brass. Rubber or neoprene gaskets must provide a positive seal against the weather.

2.4.6 Device Plates

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

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

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

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

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

2.5 BOXES AND FITTINGS

Boxes must 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 must be cast-metal with threaded hubs. Surface-mounted boxes on interior walls must be cast-metal. Boxes in other areas must 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 must 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, must be not less than [100 millimeter](#) [4 inches](#) [octagonal] [square], with plaster rings [40 millimeter](#) [1-1/2 inches](#) deep and must be capable of withstanding a vertical downward force of [890 newton](#)

200 pounds for 5 minutes. All boxes in spaces above suspended ceilings must be installed in accessible locations. Boxes in otherwise inaccessible locations must be accessible from ceiling space access panels. Ceiling-mounted outlet boxes for lighting fixtures, fittings, and wiring devices must be symmetrical, except as otherwise indicated, and must not interfere with the work of other trades.

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

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

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

Surface-mounted boxes must be outside flange type with a matching solid flat cover. Flush-mounted boxes in walls and floors must be the outside flange type with a matching recessed solid walkway cover. Box bodies and covers must 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 0.0016 cubic meter 100 cubic inches for connection to galvanized rigid steel conduits embedded in concrete or surface mounted must be watertight rectangular boxes in accordance with UL 50 and NEMA FB 1.

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

2.5.3 Pull and Junction Boxes

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

Boxes must 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 must 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 must be [cast] [hot-dipped galvanized] with threaded hubs and neoprene-gasketed covers.

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

2.5.4 RFI-Shielded Enclosures

Radio-frequency interference (RFI)-shielded enclosures must be provided where indicated to protect electrical equipment from RFI. Enclosures must 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 must conform to [UL 50](#).

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

Cabinets for electrical controls with volume greater than [0.0016 cubic meter 100 cubic inches](#) must 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 must be installed in accordance with [NFPA 70](#), and must 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 must contain not more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting. Field bends must 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 must be free of dirt and trash and must not be deformed or crushed. Empty conduit must have a pull rope stalled.

Conduit must be installed with a minimum of [75 millimeter 3 inches](#) of free air space separation from mechanical piping.

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

Conduit must be securely clamped and supported at least every [3000 millimeter 10 feet](#) vertically and [2400 millimeter 8 feet](#) horizontally. Galvanized pipe straps must be fastened to structure with bolts, screws,

and anchors. Wooden masonry plugs must not be used.

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

All recessed outlet boxes in non-combustible walls or ceilings must be installed flush, such that the outlet box is set back less than 2 millimeter 1/16 inch or protrudes less than 2 millimeter 1/16 inch from the face of the ceiling or wall.

Conduit connections to boxes and fittings must be supported not more than 900 millimeter 36 inches from the connection point. Conduit bends must be supported not more than 900 millimeter 36 inches from each change in direction. Conduit must be installed in neat symmetrical lines parallel to the centerlines of the building construction and the building outline. Multiple runs must 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, must be rigid steel conduit. Conduit joints in corrosive areas must be painted with [corrosion] [acid]-inhibiting compounds.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 1470 millimeter 5 feet 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 must be sealed to prevent the passage of air within the conduit. Conduit must be sloped to drain and must be provided with drainage fittings at the lower end of the run. Curved portion of conduit bends must not be visible above the finished floor. Underground service entrance and feeder conduit entering or leaving the building above the ground floor must be terminated in a pull box.

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

Underground portions of conduit runs must be painted with bitumastic or must be provided with a factory-applied coating of PVC not less than 5 millimeter 0.20 inch 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 must be wrapped with a single layer of 0.254 millimeter 0.010 inch thick pressure-sensitive PVC tape, half-lapped to obtain a minimum thickness of 5 millimeter 0.20 inch. Couplings must be wrapped with pressure-sensitive tape, as described above, over the coupling and for 50 millimeter 2 inches 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 must be in accordance with NFPA 70 or as indicated on the contract drawings.

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

Bushings must be provided on the open ends of conduit containing

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

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

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

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

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

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

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

3.1.1.1 Installation of Rigid Metal Conduit

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

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

At connections to sheet metal enclosures and boxes, a sufficient number of threads must project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknut must be pulled up sufficiently tight to draw the bushing into firm electrical contact with the box. Conduit must 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 must be made with tapered threads set firmly. Each length of conduit cut in the field must be reamed before installation. Where conduit is threaded in the field, each threaded end must consist of at least five full threads. Corrosion-inhibitive compound must 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 must be provided with a flush coupling if the floor slab is of sufficient thickness; if not, a floor box must be provided and set flush with the finished floor. Conduits installed for future use must 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 must 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 must be run in conduit with conductors and must be solidly connected to ground at each end. Ground wires must be sized in accordance with NFPA 70.

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

3.1.3 Installation of EMT

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

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

3.1.4 Installation of Wireways and Auxiliary Gutters

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

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

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

3.1.5 Installation of Underfloor Raceways

Ducts must be installed using preset inserts [_____] millimeter inches on center. Inserts must be 3 millimeter 1/8 inch 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 must be installed only in exposed, accessible locations in accordance with NFPA 70. A grounding green conductor must be installed in all runs. Connections to motors and vibrating equipment must be made with flexible metallic conduit.

3.2 INSTALLATION OF WIRING

Raceways must 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 must not occupy the same enclosure with light and power conductors or the same enclosure with each other. Conductors must be continuous with splices and connections made in outlet, junction, or pull boxes only. All control wiring must be continuous between components and/or terminal boards.

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

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

Conductors installed in heavy-wall rigid steel conduit and EMT must have allowable current-carrying capacity and ampere ratings in accordance with [NFPA 70](#). Larger-sized conductors must 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 must be color coded in accordance with the following:

<u>CONDUCTOR</u>	<u>120/208 COLOR</u>	<u>480/277 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 [6.5 millimeter diameter \(AWG No. 2\)](#) [AWG No. 2](#) must be manufactured with colored insulating materials. Conductors larger than [6.5 millimeter diameter \(AWG No. 2\)](#) [AWG No. 2](#) must have ends identified with colored plastic tape in outlet, pull, or junction boxes. Control circuit conductors must be identified at each connection point.

Connectors and splices must conform to [UL 486C](#) and must 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 must be thoroughly cleaned prior to makeup to ensure good electrical and mechanical connections. Conductor identification must 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 must match that shown on approved shop drawings. Hand lettering or marking is not acceptable. Control-circuit terminals of equipment must be properly identified by color-coded insulated conductors, number-coded plastic self-sticking

printed markers, or permanently attached metal-foil markers. Cable fittings must conform to **UL 514B**; insulating tape must conform to **ASTM D 2301**.

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

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

3.3 DIRECT-BURIAL CABLE

Direct-burial cable must comply with the following requirements:

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

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

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

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

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

A bright yellow PVC ribbon, minimum **50 millimeter 2 inches** wide, continuously marked CAUTION -- ELECTRICAL SERVICE BELOW must be placed on the trench approximately **200 millimeter 8 inches** 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 must 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 must be backfilled and compacted in accordance with Section **31 00 00 EARTHWORK**. Backfill must be free of roots, trash, debris, and stones.

3.4 SAFETY SWITCHES

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

3.5 WIRING DEVICES

3.5.1 Wall Switches and Receptacles

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

Ground terminal of each flush-mounted receptacle must 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 must 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 must 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 must be identified on the inside by circuit number and panelboard.

3.6 BOXES AND FITTINGS

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

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

Bonding jumpers must 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, must be as follows:

<u>LOCATION</u>	<u>MOUNTING HEIGHT</u>
Receptacles in offices	460 millimeter18 inches
Receptacles in corridors	1220 millimeter18 inches
Receptacles for clocks	2440 millimeter96 inches
Switches for light control	1220 millimeter48 inches
Thermostats	1675 millimeter66 inches

3.7 IDENTIFICATION PLATES

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

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

DANGER - EXTERNAL VOLTAGE SOURCE

3.8 FIELD TESTING

Submit [Test Reports](#) in accordance with referenced standards in this section.

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

Contractor must provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable 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 must be used to isolate the circuits under test.

Perform [Insulation-Resistance Test](#) on each field-installed conductor with respect to ground and adjacent conductors. Applied potential must be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values must not be less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes 8AWG and smaller insulation resistance testing is not required.

Perform [Continuity Test](#) to insure correct cable connection (i.e correct phase conductor, grounded conductor, and grounding conductor wiring) end-to-end. Any damages to existing or new electrical equipment resulting from contractor mis-wiring will be repaired and re-verified at contractor's expense. All repairs must be approved by the CO prior to acceptance of the repair.

Conduct [Phase-Rotation Tests](#) on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source.

Final acceptance will depend upon the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved by the CO.

-- End of Section --