Preparing Activity: NASA Superseding
UFGS-26 05 00.00 40 (August 2019)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL

11/20

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.3 SUBMITTALS
1.4 QUALITY CONTROL
1.4.1 Regulatory Requirements
1.4.2 Standard Products

PART 2 PRODUCTS

2.1 EQUIPMENT
2.1.1 Conduits and Raceways
2.1.1.1 Rigid Steel Conduit
2.1.1.2 Electrical Metallic Tubing (EMT)
2.1.1.3 Flexible Metallic Conduit
2.1.1.4 Intermediate Metal Conduit
2.1.1.5 Rigid Nonmetallic Conduit
2.1.1.6 Surface Metal Raceway
2.1.1.7 Surface Nonmetallic Raceway
2.1.2 Wireways
2.1.3 Cable Trays
2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes
2.1.5 Panelboards
2.1.5.1 Circuit Breakers
2.1.6 Dry-Type Distribution Transformers
2.1.6.1 General Requirements
2.1.6.2 Transformer Factory Tests
2.2 MATERIALS
2.2.1 Wire And Cable
2.2.1.1 Insulation
2.2.1.2 Wire and Cable for 400 Hertz (Hz) Circuits
2.2.1.3 Metal-Clad Cable
2.2.1.4 Armored Cable

2.2.1.5 Mineral-Insulated, Metal-Sheathed Cable
2.2.1.6 Cable Tray Cable or Power Limited Tray Cable
2.2.1.7 Cord Sets and Power-Supply Cords
2.2.2 Device Plates
2.2.3 Switches
2.2.3.1 Safety Switches
2.2.3.2 Toggle Switches
2.2.4 Fuses
2.2.4.1 Fuseholders
2.2.4.2 Cartridge, Current Limiting Type (Class R)
2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)
2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)
2.2.5 Receptacles
2.2.5.1 Switched Duplex Receptacles
2.2.5.2 Weatherproof Receptacles
2.2.5.3 Ground-Fault Circuit Interrupter Receptacles
2.2.5.4 Special Purpose Receptacles
2.2.5.5 Plugs
2.2.5.6 Tamper-Resistant Receptacles
2.2.6 Manufacturer's Nameplate
2.2.7 Warning Signs
2.2.8 Firestopping Materials
2.2.9 Metering
2.2.10 Surge Protective Devices

PART 3 EXECUTION

3.1 PREPARATION
3.2 INSTALLATION
3.2.1 Underground Service
3.2.2 Overhead Service
3.2.3 Hazardous Locations
3.2.4 Service Entrance Identification
3.2.5 Labels
3.2.6 Wiring Methods
3.2.6.1 Pull Wire
3.2.6.2 Metal Clad Cable
3.2.6.3 Armored Cable
3.2.6.4 Mineral Insulated, Metal Sheathed (Type MI) Cable Installation
3.2.7 Conduits, Raceways and Fittings
3.2.7.1 Rigid Steel Conduit
3.2.7.2 Electrical Metallic Tubing (EMT)
3.2.7.3 Flexible Metallic Conduit
3.2.7.4 Intermediate Conduit
3.2.7.5 Rigid Nonmetallic Conduit
3.2.7.6 Underground Conduit
3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts
3.2.7.8 Conduit Installed Under Floor Slabs
3.2.7.9 Conduit Installed Through Floor Slabs
3.2.7.10 Conduit Installed in Concrete Floor Slabs
3.2.7.11 Stub Ups
3.2.7.12 Conduit Support
3.2.7.13 Directional Changes in Conduit Runs
3.2.7.14 Wireway and Auxiliary Gutter
3.2.7.15 Surface Raceways and Assemblies
3.2.7.16 Cable Trays
3.2.8 Wiring

3.2.9 Wiring Devices
3.2.9.1 Wall Switches and Receptacles
3.2.9.2 Device Plates
3.2.10 Splices and Connectors
3.2.11 Conductor Identification
3.2.11.1 Marking Strips
3.2.12 Safety Switches
3.2.13 Boxes and Fittings
3.2.14 Covers and Device Plates
3.2.15 Electrical Penetrations
3.2.16 Panelboards
3.2.17 Dry-Type Distribution Transformers
3.2.18 Surge Protective Devices
3.2.19 Field Fabricated Nameplates
3.2.20 Identification Plates and Warnings
3.3 FIELD FABRICATED NAMEPLATE MOUNTING
3.4 WARNING SIGN MOUNTING
3.5 FIELD APPLIED MOUNTING
3.6 FIELD QUALITY CONTROL

-- End of Section Table of Contents --

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL
11/20

****
NOTE: This guide specification covers the requirements for common to all electrical sections.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

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 Reference Identifier (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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480	(1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1	(2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2022) Requirements for Watthour Meter

	Sockets
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
ANSI/NEMA OS 2	(2013; R 2020) Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2021) Wiring Devices Dimensions

Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2018H; Add 1 2019) Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
UL 4	(2004; Reprint Mar 2021) UL Standard for Safety Armored Cable
UL 5	(2016; Reprint Jul 2022) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint May 2023) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018; Reprint May 2023) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Apr 2023) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors

UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint May 2023) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2023) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1569	(2018) UL Standard for Safety Metal-Clad Cables

UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018; Reprint Feb 2022) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

[c. Vertical assembly: A vertical assembly is a pole, tower or other such support, mounting hardware, arms, brackets and the load. Load can be a luminaire, siren, loudspeaker or other device. All components of a vertical assembly will be rated by the manufacturer to withstand [217][_____] kilometer/hour [150][_____] mph wind loading in accordance with [ASCE 7-16][TIA-222].

]1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Marking Strips; G

SD-03 Product Data

Conduits and Raceways; G[, [____]]

Wire and Cable; G[, [____]]

Splices and Connectors; G[, [____]]

Switches; G[, [____]]

Receptacles; G[, [____]]

Outlet Boxes, Pull Boxes and Junction Boxes; G[, [____]]

Circuit Breakers; G[, [____]]

Panelboards; G[, [____]]

Dry-Type Distribution Transformers; G[, [____]]

Device Plates; G[, [____]]

SD-06 Test Reports

Continuity Test; G[, [____]]

Phase-Rotation Tests; G[, [____]]

Insulation Resistance Test; G[, [____]]

600-Volt Wiring Test; G[, [____]]

Transformer Tests; G[, [____]]

Ground-Fault Receptacle Test; G[, [____]]

Insulation-Resistance Test; G[, [____]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

****

NOTE: Include IEEEE C2 if directing utility work or providing overhead lines on premises that would reference tables in IEEE C2 for distance above ground, distance from buildings and structures, cable tension calculations, etc.

****

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, [IEEE C2] unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray,[and equipment located outdoors: ANSI[Light Gray][Dark Gray]].

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED MOUNTING.

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, [gland]compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquidtight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquidtight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type [5-15R] [5-20R].

UL 5, two-piece painted steel, totally enclosed, snap-cover type.[Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every [455] [_____] mm [18] [_____] inches.][Wire alternate receptacles on different circuits.]

2.1.1.7 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type.[Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every [455] [_____] mm [18] [_____] inches.][Wire alternate receptacles on different circuits.]

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 100 by 100 millimeter 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel[epoxy painted][galvanized] 16 gauge for heights and depths up to 150 by 150 mm 6 by 6 inches, and 14 gauge for heights and depths up to 305 by 305 mm 12 by 12 inches. Provide in length[indicated][required for the application] with[hinged-][screw-] cover NEMA[1][3R][12] enclosure per NEMA ICS 6.

[2.1.3 Cable Trays

NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal[[75] [100] [150] mm [3] [4] [6] inch] depth[as indicated].

b. Cable trays: constructed of[aluminum][copper-free aluminum][steel that has been zinc-coated after fabrication].

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

[f. Radius of bends: [[305] [610] [915] mm [12] [24] [36] inches.][as indicated.]
]

****

NOTE: Basket cable tray is a fabricated structure consisting of wire mesh bottom and side rails.
****

Provide basket-type cable trays [size as indicated][of nominal[50,][100,][150,][200,][300,][450,][and][600] mm[2,][4,][6,][8,][12,][18,][and][24] inch width and [25,][50,][and][100] mm[1,][2,][and][4] inch depth] with maximum wire mesh spacing of 50 by 100 mm 2 by 4 inch.

****
NOTE: Trough or ventilated cable tray is a fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and utilizing 75 percent or less of the plan area of the surface to support cables.
****

[Provide trough-type cable trays [size as indicated.][of nominal [150] [305] [455] [610] [760] [915] mm [6] [12] [18] [24] [30] [36] inch width.]]

****
NOTE: Ladder cable tray is a fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
****

[Provide ladder-type cable trays [size as indicated][of nominal [150] [305] [455] [610] [760] [915] mm [6] [12] [18] [24] [30] [36] inch width] with maximum rung spacing of [150] [225] [305] [455] mm [6] [9] [12] [18] inches.]

****
NOTE: Channel cable tray is a fabricated structure consisting of a one-piece ventilated-bottom or solid-bottom channel section, not exceeding 152 mm 6 inches in width.
****

[Provide channel-type cable trays [size as indicated.][of nominal [75] [100] [150] mm [3] [4] [6] inch width]. Provide trays with one-piece construction having slots spaced not more than 115 mm 4 1/2 inches on centers.]

****
NOTE: Solid bottom or non-ventilated cable tray is a fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
****

[Provide solid bottom-type cable trays [size as indicated][of nominal [150] [305] [455] [610] [760] [915] mm [6][12][18][24][30][36] inch width]. [Provide solid covers.][Do not provide solid covers.]

][Provide cantilever [size as indicated][of nominal [75] [100] [150] mm [3] [4] [6] inch width]. Provide trays with one-piece construction having slots spaced not more than 115 mm 4 1/2 inches on centers.]

]2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and [ANSI/NEMA OS 1] [ANSI/NEMA OS 2] and are not less than 40 millimeter 1-1/2 inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.5 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for [240-volt (maximum), single-phase] [120/208-volt, three-phase] [277/480-volt, three-phase], 60-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted["above"][or]["below"] branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Provide[[tinned] copper][aluminum] buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. [Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors.][In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated.]Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

Support bus bars on bases independent of circuit breakers. Design main

buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.1.5.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 [and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES]with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous [thermal-magnetic][electronic][solid-state] tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than [100][250][_____] ampere.[Provide circuit breakers with frame sizes [100][250][_____] ampere and larger with [electronic][solid-state] trip units equipped with adjustable long-time[,] [short-time][and][ground-fault] settings in addition to instantaneous.]

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is [not]permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 40 degrees C 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.6 Dry-Type Distribution Transformers

2.1.6.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL 506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA[1][3R][_____] enclosure.

Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater,

with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.6.2 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.2 MATERIALS

2.2.1 Wire And Cable

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts,[Type THWN/THHN conforming to UL 83][or][Type[XHHW][or][RHW] conforming to UL 44], except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

[2.2.1.2 Wire and Cable for 400 Hertz (Hz) Circuits

Insulated copper conductors.

][2.2.1.3 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

][2.2.1.4 Armored Cable

UL 4; NFPA 70, Type AC cable.

][2.2.1.5 Mineral-Insulated, Metal-Sheathed Cable

UL listed; NFPA 70, Type MI cable. Do not use sheathing containing asbestos fibers.

][2.2.1.6 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

][2.2.1.7 Cord Sets and Power-Supply Cords

UL 817.

]2.2.2 Device Plates

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

[d. Plates on finished walls: nylon or lexan, minimum 0.792 mm 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.

][e. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.792 mm 0.03 inch thick.

] f. Screws: machine-type with countersunk heads in color to match finish of plate.

g. Sectional type device plates are not be permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

[i. Device plates in areas normally accessible to prisoners: brown or ivory finish nylon-device plates rated for high abuse. Test device plates for compliance with UL 514A and UL 514C for physical strength. Attach device plates with spanner head bolts.

]2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover

release device is coinproof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED), and fluorescent lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, [single] [double]-pole, [three] [four]-way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

NEMA FU 1. Provide complete set of fuses for each fusible[switch][panel][and control center]. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers[or other circuit protective devices] for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class[RK-1][RK-5][time-delay type]. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles

****

NOTE:1. Designer will select the proper grade for the application. Hard use receptacles (called heavy duty receptacles by some manufacturers)are suitable for normal use and heavy use. Use hospital grade

receptacles only for those applications that exceed capabilities of hard use. Residential-grade receptacles are not acceptable.

2. Thermoplastic components provide superior resistance to impacts, chemicals and solvents as compared to thermoset materials. Nylon, Polycarbonate, Polyester, Acrylic and Polypropylene are examples of thermoplastic material. Phenolic. Urea and Melamine are examples of thermoset materials which do not provide high degrees of resistance to impact.

****

Provide the following:

a. [UL 498, hard use (also designated heavy-duty),][UL 498, hospital grade,] grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: [white][ivory][brown] as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

****

NOTE: Provide die-cast metal/aluminum cover plate when matching existing installation.

****

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, [polycarbonate, UV resistant/stabilized][die-cast metal/aluminum] cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

****

NOTE: Ground-fault circuit interrupters are spelled out rather than abbreviated as "GFCI" to avoid a potential conflict with "government furnished, contractor installed equipment".

****

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.2.5.4 Special Purpose Receptacles

Receptacles serving [_____] are special purpose.[Provide in ratings indicated.][NEMA [_____] configuration, rated [_____] amperes, [_____] volts.][Furnish one matching plug with each receptacle.]

[2.2.5.5 Plugs

Provide heavy-duty, rubber-covered[three-,][four-,][or][five-]wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

]2.2.5.6 Tamper-Resistant Receptacles

****

NOTE: NFPA 70 defines a tamper-resistant receptacle as one which by its construction limits improper access to its energized parts.

****

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with [IEEE C57.12.28][IEEE C57.12.29], such as for pad-mounted transformers[and pad-mounted SF6 switches]. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 178 by 255 mm 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 50 mm 2 inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.[Use Panduit decal No. PPSO710D72 or approved equal.]

[b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 355 by 255 mm 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in

three lines of nominal 75 mm 3-inch high white letters on a red and black field.

]2.2.8 Firestopping Materials

Provide firestopping around electrical penetrations in accordance with Section 07 84 00, FIRESTOPPING.

2.2.9 Metering

ANSI C12.1. Provide a self-contained, socket-mounted, electronic programmable outdoor watthour meter. Meter: either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

****
NOTE: Form 2S, in text below, is for single-phase, three-wire systems. For other system configurations, determine the appropriate form designation. Class 200 meters are for 100A and 200A services.
****

a. Design: Provide watthour meter designed for use on a single-phase, three-wire,[240/120][480/240] volt system. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Class: 200; Form: [2S][_____], accuracy: plus or minus 1.0 percent; Finish: Class II.

c. Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on the meter face.

(3) Demand interval length: programmed for[15][30][60] minutes with rolling demand up to six subintervals per interval.

f. Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having [manual circuit-closing bypass and having]jaws compatible with requirements of the meter. Provide manufacturers standard enclosure color unless otherwise indicated.

2.2.10 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance[, load centers] [, panelboards] [, MCC] [and] [_____]. Provide surge protectors in a NEMA[1][_____] enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
[Neutral to ground (N-G)]
[Phase to ground (L-G)]

[FOR DELTA CONNECTIONS-
Phase to phase (L-L)
Phase to ground (L-G)

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

****
NOTE: Select the first bracketed section below when surge protection is installed as part of a lightning protection system per NFPA 780. Select the second bracketed option below if the surge protection is not part of a lightning protection system; the second bracketed option values are based on manufacturers' standard products and are not as restrictive as NFPA 780.
****

[Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, L-G, and N-G Voltage Protection Rating:

[600V for 120V, single phase system]
[600V for 120/240V, single phase system]
[600V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

][Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

[700V for 120V, single phase system]
[700V for 120/240V, single phase system]
[700V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[2,000V for 480Y/277V, three phase system]

] The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below;

115% of nominal voltage above 240 volts to 480 volts.

****
NOTE: Provide EMI/RFI filtering when required by project documents.
****

[Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

]PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

****
NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS and 09 90 00 PAINTS AND COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation will break down most standard coatings, causing a phenomena known as chalking, which is the first stage of the corrosion process. For additional information contact The Coatings Industry Alliance, specific suppliers such as Keeler and Long and PPG, and NACE International (NACE).
****

Clean and paint conduit, supports, fittings, cabinets, pull boxes, and racks as specified in [Section 09 90 00 PAINTS AND COATINGS][Section 09 96 00 HIGH-PERFORMANCE COATINGS].

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and abrasive action), and all outdoor installations, refer to Section [09 96 00 HIGH-PERFORMANCE COATINGS][09 90 00 PAINTS AND COATINGS]. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.2.2 Overhead Service

Overhead service conductors into buildings: terminate at service entrance

fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.2.3 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.2.5 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 6.35 mm 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.2.6 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways.[Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters.] Minimum conduit size: 16 mm 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 150 mm 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00, FIRESTOPPING.

3.2.6.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 890-N 200-pound force tensile strength. Leave minimum 915 mm 36 inches of slack at each end of pull wire.

[3.2.6.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

][3.2.6.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

][3.2.6.4 Mineral Insulated, Metal Sheathed (Type MI) Cable Installation

Mineral-insulated, metal-sheathed cable system, Type MI, may be used in lieu of exposed conduit and wiring. Conductor sizes: not less than those indicated for the conduit installation. Fasten cables within 305 mm 12 inches of each turn or offset and at 830 mm 33 inches maximum intervals. Make cable terminations in accordance with NFPA 70 and cable manufacturer's recommendations. Terminate single-conductor cables of a circuit, having capacities of more than 50 amperes, in a single box or cabinet opening. Color code individual conductors in all outlets and cabinets.

]3.2.7 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

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).

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 150 mm 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.[Run conduits[in crawl space][under floor slab] as if exposed.

]3.2.7.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 65 millimeter 2-1/2 inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.7.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.7.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet

boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquidtight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

Provide flexible steel conduit between 915 and 1830 mm 3 and 6 feet in length for recessed and semirecessed lighting fixtures[; for equipment subject to vibration, noise transmission, or movement; and for motors]. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 16 mm 1/2 inch diameter. Provide liquidtight flexible[nonmetallic] conduit in wet and damp locations[and in fire pump rooms] for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.2.7.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.7.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.7.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40[; or fiberglass. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab.] Plastic coating: extend minimum 150 mm 6 inches above floor.

3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.7.8 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of [305] [_____] mm [12] [_____] inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.2.7.9 Conduit Installed Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab.

3.2.7.10 Conduit Installed in Concrete Floor Slabs

[Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40.][PVC, Type EPC-40, unless indicated otherwise.] Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of

concrete slab.[Do not stack conduits.][Do not stack conduits more than two diameters high with minimum vertical separation of [_____] mm inches.] Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum 25 mm one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than 27 mm one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab.[Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.]

3.2.7.11 Stub Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 150 mm 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.2.7.12 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 40 mm 1 1/2 inches in reinforced concrete beams or to depth of more than 20 mm 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations.[Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 3050 mm 10 foot maximum intervals.] Where conduit crosses building expansion joints, provide suitable[watertight] expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 63 mm 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.2.7.13 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or

conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.2.7.14 Wireway and Auxiliary Gutter

Bolt together straight sections and fittings to provide a rigid, mechanical connection and electrical continuity. Close dead ends of wireways and auxiliary gutters. Plug all unused conduit openings.

Support wireways for overhead distribution and control circuits at maximum [_____] [1500] millimeter [5]-foot intervals.

Ensure auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure contains no switches, overcurrent devices, appliances, or apparatus and is not more than [_____] [9000] millimeter [30] feet long.

3.2.7.15 Surface Raceways and Assemblies

Mount surface raceways plumb and level, with the base and cover secured. Minimum circuit run is three-wire, with one wire designated as ground.

3.2.7.16 Cable Trays

Support cable trays from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Provide support when the free end extends beyond [_____][900] millimeter [3] feet. Maximum support spacing is [_____][1800] millimeter [6] feet. Support trays 250 millimeter 10-inches wide or less by [one] [_____] hanger. Support trays greater than 250 millimeter 10 inches wide by [two] [_____] hangers. Bond cable trays at splices.

3.2.8 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	[Green] [Green with Yellow Stripe] [Bare]

Use conductors up to and including 6.5 millimeter diameter AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than 6.5 millimeter diameter AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at

the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

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

3.2.9 Wiring Devices

3.2.9.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within [_____][2] millimeter [1/16] inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.9.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having [_____][6] millimeter [1/4] inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.10 Splices and Connectors

Make all splices in 3.15 millimeter diameter AWG No. 8 and smaller with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Make all splices in 4.1 millimeter diameter AWG No. 6 and larger with [indentor crimp-type connectors and compression tools][insulated electrical lugs type] . Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.11 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with[Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.][Section [_____], [_____]][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][manufacturer's recommendations].[Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.]

3.2.11.1 Marking Strips

Provide marking strips in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.2.12 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of [four] [_____] 6 millimeter 1/4 inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height [_____][1500] millimeter [5] feet above floor level, when possible.

3.2.13 Boxes and Fittings

Provide pullboxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than [_____] [30] meter [100] feet or with more than three right-angle bends, install a pullbox at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

Select the mounting height of wall-mounted outlet and switch boxes, as measured between the bottom of the box and the finished floor, in accordance with ICC/ANSI A117.1 and as follows, unless otherwise indicated:

LOCATION	MOUNTING HEIGHT
Receptacles in offices	450 millimeter
Receptacles in corridors	450 millimeter
Receptacles in shops and laboratories	1200 millimeter
Receptacles in rest rooms	1200 millimeter
Switches for light control	1200 millimeter

LOCATION	MOUNTING HEIGHT (inches)
Receptacles in offices	18
Receptacles in corridors	18
Receptacles in shops and laboratories	48
Receptacles in rest rooms	48
Switches for light control	48

3.2.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 0.58 mm 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.2.15 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.2.16 Panelboards

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NOTE: Ability to remove access covers is required for maintenance activities. In addition, access may be required to inspect this device while circuits are energized (for example, using infrared imaging). Minimum distances to energized circuits is specified in OSHA Standards Part 1910.333 (Electrical - Safety-Related work practices). OSHA Standards are available on the internet.
****

Securely mount panelboards so that the top operating handle does not exceed [_____][1800] millimeter [72]-inches above the finished floor. Do not mount equipment within 914 millimeter 36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.17 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

[Mount all dry-type transformers on vibration isolators in accordance with Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

]3.2.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 900 mm 3 feet.

3.2.19 Field Fabricated Nameplates

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NOTE: Use the following paragraph where nameplates are fabricated to identify specific equipment designated on the drawings.
****

Ensure nameplates conform to ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 3 mm 0.125-inch thick, white with [black] [_____] center core and a matte finish surface [with square corners]. Accurately align lettering and engrave into the core. Minimum size of nameplates is 25 by 65 mm 1 by 2.5 inches. Lettering is a minimum of 6.35 mm 0.25-inch high normal block style.

3.2.20 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent

surfaces or to meet the indicated or specified safety criteria. [Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.][Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.]

3.6 FIELD QUALITY CONTROL

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NOTE: If the specified system is identified as critical, configured, or mission essential, use Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.

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Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

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.

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. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 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 is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes 3.15 millimeter diameter AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement 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 in a clockwise direction, facing the source.

Perform 600-volt wiring test on wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

-- End of Section --