UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
****

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SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

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USACE / NAVFAC / AFCEC / NASA	**UFGS-26 20 00 (August 2019)** **Change 1 - 11/19**
Preparing Activity: NAVFAC	**Superseding** **UFGS-26 20 00 (February 2014)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
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NOTE: This guide specification covers the requirements for the procurement, installation, and testing of electrical wiring systems for construction projects.

Telecommunications cabling is covered in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. These wiring systems primarily involve voltages of 1,000 volts and less and mainly involve interior systems. When voltages greater than 1,000 volts are brought into a facility, consult and use Section 26 11 16 SECONDARY UNIT SUBSTATIONS; Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS; and Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Also consult Section 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION. Add requirements for materials and procedures for special or unusual design as necessary to fit specific projects.

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).

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NOTE: Ensure the following information is shown on the project drawings:

1. Location of equipment

2. Single-line diagrams elevations, limiting dimensions, and equipment ratings which are not covered in the specifications

3. Remote indicating or control requirements.

****

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

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2014) Requirements for Watthour Meter Sockets
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2015) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
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 MG 1	(2018) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
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	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-569	(2015d) Commercial Building Standard for

	Telecommunications Pathways and Spaces
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.303	Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit
UL 4	(2004; Reprint Feb 2018) UL Standard for Safety Armored Cable
UL 5	(2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 44	(2018) 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 Jul 2020) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Oct 2020) UL Standard for Safety Liquid-Tight Flexible Metal Conduit

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2019) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Aug 2020) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) 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 Mar 2020) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 674	(2011; Reprint Nov 2018) UL Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL 719	(2015; Reprint Nov 2018) UL Standard for Safety Nonmetallic-Sheathed Cables
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 845	(2005; Reprint Oct 2018) UL Standard for Safety Motor Control Centers
UL 854	(2020) Standard for Service-Entrance Cables
UL 857	(2009; Reprint Aug 2016) UL Standard for

	Safety Busways
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 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1242	(2006; Reprint Aug 2020) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2014; Reprint Jul 2017) 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 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017) UL Standard for Safety Arc-Fault Circuit-Interrupters
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 4248-1	(2017) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms

used in these specifications, and on the drawings, are as defined in IEEE 100.

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

Panelboards; G[, [_____]]

Transformers; G[, [_____]]

Busway; G[, [_____]]

Cable Trays; G[, [_____]]

Motor Control Centers; G[, [_____]]

Wireways; G[, [_____]]

[Load Centers for Housing Units; G[, [_____]]

] Marking Strips Drawings; G[, [_____]]

SD-03 Product Data

Receptacles; G[, [_____]]

Circuit Breakers; G[, [_____]]

Switches; G[, [_____]]

Transformers; G[, [_____]]

Enclosed Circuit Breakers; G[, [_____]]

Motor Controllers; G[, [_____]]

[Combination Motor Controllers; G[, [_____]]

][Load Centers for Housing Units; G[, [_____]]

] Manual Motor Starters; G[, [_____]]

[Residential Load Centers; G[, [_____]]

][Metering; G[, [_____]]

][Meter Base Only; G[, [_____]]

] CATV Outlets; G[, [_____]]

Telecommunications Grounding Busbar; G[, [_____]]

Surge Protective Devices; G[, [_____]]

SD-06 Test Reports

600-volt Wiring Test; G[, [_____]]

Grounding System Test; G[, [_____]]

Transformer Tests; G[, [_____]]

Ground-fault Receptacle Test; G[, [_____]]

Arc-fault Receptacle Test; G[, [_____]]

SD-07 Certificates

Fuses; G[, [_____]]

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

[SD-10 Operation and Maintenance Data

****
NOTE: Coordinate with options under paragraphs MAINTENANCE" and METERING.
****

Electrical Systems, Data Package 5; G[, [_____]]

[Metering, Data Package 5; G[, [_____]]

]]1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" 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. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 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 and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

****
NOTE: Select the option below only if the system is considered complex and there is a need for detailed system information.
****

[1.5.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

]1.6 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

[1.7 SEISMIC REQUIREMENTS

****
NOTE: Do not use this paragraph for Navy projects. When directed to meet seismic requirements, edit Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT to suit the project and include in the contract documents. Edit the following paragraph and include it in the project specification. When a Government designer is the Engineer of Record, provide seismic requirements on the drawings.
****

Provide seismic details[conforming to[Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT][and to][Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT]][as indicated].

]PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

****

NOTE: The Uses Permitted are as modified by UFC 3-520-01, "Interior Electrical Systems." The Uses Not Permitted are as specified in NFPA 70 and when restricted by other UFCs for specific types of buildings, such as medical facilities. Do not use flexible metal conduit in damp and wet locations and for pumps. Do not use Electrical Nonmetallic Tubing (ENT).

Use malleable iron seal electrical fittings in fuel valve pits and similar locations where fittings are exposed to potential freeze thaw environments. Nonmetallic fittings have failed in these environments.

****

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40[, and EPC-80] in accordance with NEMA TC 2,UL 651[, or fiberglass conduit, in accordance with NEMA TC 14].

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(1 mm 40 mils thick).

2.2.6 Flexible Metal Conduit

UL 1.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with

UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

****
NOTE: Moisture absorbed within die-cast fittings may cause them to deteriorate more rapidly than steel fittings. Utilize steel fittings in damp or wet locations, or when requested by Activity on Installations and Bases that have high ambient humidity environments.
****

[Die Cast][Steel] compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC[and NEMA TC 14 for fiberglass], and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

****
NOTE: Do not use liquid-tight flexible nonmetallic conduits in Continental United States (CONUS). In overseas locations, only use when specifically allowed by the Authority Having Jurisdiction.
****

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

****
NOTE: UFC 3-520-01 authorizes the use of surface metal raceway only for building improvements, renovations or for applications where a variety of cord-and-plug connected equipment will be utilized in a limited space, such as in some areas of medical facilities, shops, and laboratories. Authorized for use on acoustic-rated walls to limit the number of penetrations and maintain acoustical integrity. Typical applications include spaces such as Sensitive Compartmented Information Facilities (SCIF) and Special Access Program Facilities (SAPF).
****

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.]

2.3.2 Surface Nonmetallic Raceway

****
NOTE: The UFC 3-520-01 definition of "subject to physical damage" prohibits the use of nonmetallic wireways for exterior applications installed less than 2.4 meters 8 feet above finished grade or 2.4 meters 8 feet above floor elevation for raceways on elevated platforms, loading docks, or stairwells. Coordinate with the Authority Having Jurisdiction responsible for the construction contract regarding the use of this wiring method in the project.
****

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.]

2.4 BUSWAY

****
NOTE: Ensure phase sequence of voltages and orientation are indicated on the drawings for existing transformers, switchboards, switchgear, and motor control centers.
****

NEMA BU 1.1, UL 857. Provide the following:

a. Buses: [copper][or][aluminum].

b. Busways: rated [_____] volts, [_____] continuous current amperes, three-phase,[three-][four-]wire, and include integral or internal[50-percent] ground bus.

c. Short circuit rating: [[_____] root mean square (rms) symmetrical amperes minimum][as indicated].

[d. Busway systems: suitable for use indoors.

] e. Enclosures: [steel] [aluminum] [metallic].

f. Hardware: plated or otherwise protected to resist corrosion.

g. Joints: one-bolt type with through-bolts, which can be checked for tightness without de-energizing system.

h. Maximum hot spot temperature rise at any point in busway at continuous rated load: do not exceed 55 degrees C above maximum ambient temperature of 40 degrees C in any position.

i. Internal barriers to prevent movement of superheated gases.

j. Coordinate proper voltage phasing of entire bus duct system, for example where busway interfaces with transformers, switchgear, switchboards, motor control centers, and other system components.

2.4.1 Feeder Busways

Provide[ventilated, except that vertical busways within 1830 mm 6 feet of floors must be unventilated,][unventilated, totally enclosed] low-impedance busway. Provide bus bars fully covered with insulating material, except at stabs. Provide an entirely polarized busway system.

2.4.2 Plug-In Busways

Unventilated type. Provide the following:

a. Plug-in units: [fusible, handle-operated, switch type, horsepower-rated][circuit breaker-type][handle-operated, switch type, equipped with high interrupting-capacity, current-limiting fuses].

b. Bus bars: covered with insulating material throughout, except at joints and other connection points.

[c. A hook stick of suitable length for operating plug-in units from the floor.

]2.5 CABLE TRAYS

****
NOTE: Indicate cable tray layout on the drawings. When multiple types and sizes are used, indicate size and type of cable trays on the drawings. When using "as indicated" option, ensure information required is shown on the drawings.
****

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.]

2.5.1 Basket-Type Cable Trays

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

Provide[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.

2.5.2 Trough-Type Cable Trays

****
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[size as indicated][of nominal [150] [305] [455] [610] [760] [915] mm [6] [12] [18] [24] [30] [36] inch width].

2.5.3 Ladder-Type Cable Trays

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

Provide[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.

2.5.4 Channel-Type Cable Trays

****
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[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.

2.5.5 Solid Bottom-Type Cable Trays

****
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[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.]

[2.5.6 Cantilever

Cantilever-type, center-hung cable trays may be provided at the Contractor's option in lieu of other cable tray types specified.

][2.6 OPEN TELECOMMUNICATIONS CABLE SUPPORT

****
NOTE: Utilize open telecommunications cable supports (J-Hooks / J-Supports / D-rings) only as specifically permitted in UFC 3-580-01, Telecommunications, Building Cabling System.
****

2.6.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide[[galvanized][zinc-coated][stainless] steel] open top cable supports[as indicated].

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Provide[[galvanized][zinc-coated][stainless] steel] closed ring cable supports[as indicated].

]2.7 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.7.1 Floor Outlet Boxes

Provide the following:

a. Boxes: [adjustable][nonadjustable] and concrete tight.

b. Each outlet: consisting of [nonmetallic][or][cast-metal] body with threaded openings,[or sheet-steel body with knockouts] for conduits,[adjustable][,][brass flange] ring, and cover plate with [19][25][31.75][53.92] mm [3/4][1][1 1/4][2 1/8] inch threaded plug.

c. Telecommunications outlets: consisting of[surface-mounted, horizontal][flush], aluminum or stainless steel housing with a receptacle as specified and[25 mm one inch bushed side opening][19 mm 3/4 inch top opening].

d. Receptacle outlets: consisting of[surface-mounted, horizontal][flush] aluminum or stainless steel housing with duplex-type receptacle as specified herein.

e. Provide gaskets where necessary to ensure watertight installation.

[f. Provide plugs with installation instructions to the Contracting Officer for [5] [_____] percent of outlet boxes for the capping of outlets upon removal of service fittings.

]2.7.2 Outlet Boxes for Telecommunications System

****
NOTE: When using "as indicated" option, ensure information required is shown on the drawings. Choose 100 mm 4 inch square boxes for single gang, four outlet, copper telecommunications configurations that do not have provision for fiber optic cabling. Choose 120 mm 4 11/16 inch square boxes for 35 mm 1 1/4 inch conduit installations and for outlet boxes that have or may require fiber optic cabling. Larger boxes are required to meet bend radii requirements for fiber optic cable.
****

Provide the following:

a. Standard type[100 mm square by 54 mm deep][120 mm square by 54 mm deep][4 inches square by 2 1/8 inches deep][4 11/16 inches square by 2 1/8 inches deep].

[b. Outlet boxes for wall-mounted telecommunications outlets: 100 by 54 by 54 mm 4 by 2 1/8 by 2 1/8 inches deep.

] c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.

[d. Outlet boxes for fiber optic telecommunication outlets: include a minimum 10 mm 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum 27 mm one inch conduit system.

][e. Outlet boxes for handicapped telecommunications station: 100 by 54 by 54 mm 4 by 2 1/8 by 2 1/8 inches deep.

][2.7.3 Clock Outlet for Use in Other Than Wired Clock System

****
NOTE: Battery-operated clocks are Navy standard. Retain this paragraph only under special conditions.
****

Provide the following:

a. Outlet box with plastic cover, where required, and single receptacle with clock outlet plate.

b. Receptacle: recessed sufficiently within box to allow complete insertion of standard cap, flush with plate.

c. Suitable clip or support for hanging clock: secured to top plate.

d. Material and finish of plate: as specified in paragraph DEVICE PLATES of this section.

]2.8 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 1640 mL 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type [3R][4X][_____][as indicated].

2.9 WIRES AND CABLES

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.

2.9.1 Conductors

****
NOTE: UFC 3-520-01 allows the use of aluminum conductors of equivalent ampacity instead of copper for #4 AWG and larger sizes. If only copper is desired for these applications, select the bracketed option below. The second bracketed option follows the UFC guidance.
****

****
NOTE: In overseas locations, for conductors No. 10 AWG and smaller diameter, give consideration to the use of stranded wires, if suitable terminal devices can be applied which enable proper connection. Also, stranded wires in sizes No. 10 AWG and smaller diameter may be required for projects involving uninterrupted power supply (UPS) installations.
****

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

e. [All conductors: copper.][Conductors indicated to be No. 6 AWG or smaller diameter: copper. Conductors indicated to be No. 4 AWG and larger diameter: either copper or aluminum, unless type of conductor material is specifically indicated, or specified, or required by equipment manufacturer.]

[2.9.1.1 Equipment Manufacturer Requirements

****
NOTE: Use this paragraph only if aluminum conductors are allowed.
****

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

][2.9.1.2 Aluminum Conductors

****
NOTE: In certain instances it may be necessary to require compact stranding, i.e., when outside diameter of cable must be limited. When necessary, specify the following: "Provide conductors with compact stranded utilizing method of stranding specified in ASTM B400/B400M; however, provide conductor material as specified herein."
****

Provide aluminum conductors of AA-8000 series electrical grade aluminum alloy conductors. Type EC/1350 aluminum is not acceptable. If Contractor chooses to provide aluminum for conductors No. 4 AWG and larger diameter, Contractor is responsible for increasing conductor size to have same ampacity as copper size indicated; increasing conduit and pull box sizes to accommodate larger size aluminum conductors in accordance with NFPA 70; ensuring that pulling tension rating of aluminum conductor is sufficient; providing panelboards[and motor control centers] that are UL listed for use with aluminum, and so labeled; relocating equipment, modifying equipment terminations, resizing equipment; and resolving problems that are direct results of providing aluminum conductors in lieu of copper.

]2.9.1.3 Minimum Conductor Sizes

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.

e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category [5 UTP][_____] cables[in EMT conduit][in accordance with DLVLC system manufacturer requirements].

2.9.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.9.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.9.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

[d. On three-phase, four-wire delta system, high leg: orange, as required by NFPA 70.

]2.9.3 Insulation

****

NOTE: Be sure conduit fill calculations are based on largest diameter insulation type allowed. Designer may select other insulation types which may be more suitable for a particular project. For rewiring project where existing conduit is to be utilized, specify types THHN and THWN. Refer to NFPA 70 Article 110.14 Temperature Limitations for conductor temperature rating requirements.

****

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.

2.9.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.9.4.1 Telecommunications Bonding Backbone (TBB)

****

NOTE: A Telecommunication Bonding Backbone (TBB) is required between the telecommunications main grounding busbar (TMGB) and all telecommunications

grounding busbars (TGBs). A TBB is not required for installation with only a single TGB or TMGB.

Sizing of the TBB	
TBB length linear m ft	**TBB Size (AWG)**
less than 4 13	**6**
4 - 6 14 - 20	**4**
6 - 8 21 - 26	**3**
8 - 10 27 - 33	**2**
10 - 13 34 - 41	**1**
13 - 16 42 - 52	**1/0**
16 - 20 53 - 66	**2/0**
greater than 20 66	**3/0**

Choose the second bracketed options where lightning protection system is provided in the job and specified in other sections.

Choose insulated TBB when pathway is a dissimilar metal than copper.

****

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG.[Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.]

2.9.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (TMGB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

[2.9.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

][2.9.6 Nonmetallic Sheathed Cable

****

NOTE: UFC 3-520-01 authorizes Type NC and NMC cables only in one- and two-family dwellings including attached or detached garages and storage buildings.

****

UL 719, Type NM or NMC.

][2.9.7 Wire and Cable for 400 Hertz (Hz) Circuits

Insulated copper conductors.

][2.9.8 Metal-Clad Cable

****
NOTE: Type MC cable is UL listed and NFPA 70 recognized for most common building applications. Review NFPA 70. MC cable does not protect conductors as well as rigid conduit but is more flexible to install and relocate. For Navy projects, consult with NAVFAC cognizant FEC electrical design branch manager and obtain written approval before specifying this wiring method.
****

****
NOTE: UFC 3-520-01 prohibits using Type MC cable except for branch circuits in the following dry locations: new construction and renovations in exposed locations; concealed in renovations in existing areas where walls and ceilings are not disturbed; and cable trays.
****

UL 1569; NFPA 70, Type MC cable.

][2.9.9 Armored Cable

****
NOTE: UFC 3-520-01 prohibits using Type AC cable except for branch circuits in the following dry locations: new construction and renovations in exposed locations; concealed in renovations in existing areas where walls and ceilings are not disturbed; and cable trays.
****

UL 4; NFPA 70, Type AC cable.

][2.9.10 Mineral-Insulated, Metal-Sheathed Cable

****
NOTE: Type MI cable is used for low temperature, high temperature, hazardous locations, life safety, and heating applications. Refer to NFPA 70. Clearly show the MI cable on the drawings. If MI cable utilized in hazardous areas is likely to be subject to high voltage surges, consider the use of surge suppressors in electrical panels serving the load from outside of the hazardous area. Locate suppressors in appropriately rated enclosures within the hazardous area only if there is no other option. MI cable is not available in ratings above 600 volts.
****

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

][2.9.11 Flat Conductor Cable

****
NOTE: Type FCC cable has been listed by UL and recognized by NFPA 70 for under carpet tile applications. Review NFPA 70. FCC cable is available off the shelf for power and telecommunications transmission applications.
****

UL listed; NFPA 70, Type FCC.

][2.9.12 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

][2.9.13 Cord Sets and Power-Supply Cords

****
NOTE: Include this paragraph when equipment utilizing cord sets is permanently connected to boxes in lieu of use of plug and receptacles.
****

UL 817.

]2.10 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.11 DEVICE PLATES

****
NOTE: Use last item below for brig facilities only.
****

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.

]2.12 SWITCHES

2.12.1 Toggle Switches

****
NOTE: Do not use solderless pressure type toggle switches on Navy projects.
****

NEMA WD 1, UL 20,[single pole][, double pole][, three-way][, and four-way], totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

a. Handles: [white][ivory][brown] thermoplastic.

b. Wiring terminals: screw-type, side-wired[or of the solderless pressure type having suitable conductor-release arrangement].

c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.

d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.12.2 Switch with Red Pilot Handle

NEMA WD 1. Provide the following:

a. Pilot lights that are integrally constructed as a part of the switch's handle.

b. Pilot light color: red and illuminate whenever the switch is closed or "on".

c. Pilot lighted switch: rated 20 amps and 120 volts or 277 volts as indicated.

d. The circuit's neutral conductor to each switch with a pilot light.

2.12.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.12.4 Disconnect Switches

****

NOTE: Select heavy duty-type for those switches requiring frequent operation and indicate as such on the drawings. Use NEMA 4X stainless steel switch enclosures for switches located on building exteriors in areas where salt spray or extended high humidity is a concern.

****

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA[1][3R] [4X Type 304 stainless steel][4X fiberglass][4X plastic][_____], enclosure[as indicated] per NEMA ICS 6.

2.13 FUSES

****

NOTE: Determine the proper fuse class and type based on the requirements of the electrical system and the equipment serviced. This note briefly summarizes some of the UL fuse standards and their application. In addition to 200,000 ampere rms symmetrical UL listing, 300,000 ampere rms symmetrical special purpose rating has been witnessed on UL tested and certified Class RK1, J and Class L.

UL 198, Class R: 200,000 ampere, rms symmetrical interrupting rating, RK1 is labeled current limiting, and is available in dual-element time-delay and non-time-delay options. RK5 fuses are dual-element time-delay and labeled current-limiting. Both RK1 and RK5 fuses are rejection type which should be used with rejection mounting on new equipment to satisfy high current interrupting listing by UL. However, these fuses may be used on existing equipment that is non-rejection type as a direct replacement for UL 198 fuses.

UL 198, Classes J, L, and CC: 200,000 ampere, rms symmetrical interrupting rating is available with time-delay option, is not interchangeable with any other UL fuse class, is labeled current-limiting, and is rated 600 volts ac.

UL 198, Class H: Maximum 10,000 ampere, symmetrical interrupting rating. Use only in existing equipment where the available fault is known to be less than 10,000 amperes.

UL 198, Class T: Maximum 200,000 ampere symmetrical interrupting rating. Is not interchangeable with other UL fuse classes.

****

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.

2.13.1 Fuseholders

Provide in accordance with UL 4248-1.

2.13.2 Cartridge Fuses, 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.

2.13.3 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.

2.13.4 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.

2.14 RECEPTACLES

****

NOTE: 1. Provide general purpose convenience receptacles that are specification grade, 20 A, 120 V, duplex. Identify locations where split receptacles will be used with one receptacle controlled by a separate toggle switch. Provide GFI and AFCI protection in accordance with NFPA 70. Use hospital grade receptacles only for those applications that exceed capabilities of specification grade receptacles. 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, general purpose specification grade,][UL 498, hospital grade,] grounding-type. Residential grade receptacles are not acceptable.

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.

2.14.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.14.2 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.

2.14.3 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 when the current to ground is 6 milliamperes or higher, 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.

2.14.4 Special Purpose Receptacles

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

[2.14.5 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.

]2.14.6 Range Receptacles

NEMA 14-50 configuration,[flush mounted for housing units,] rated 50 amperes, 125/250 volts.[Furnish one matching plug with each receptacle.]

2.14.7 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts.[Furnish one matching plug with each receptacle.]

2.14.8 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.

2.14.9 Arc-Fault Circuit Interrupter Receptacles

UL 1699, duplex type for mounting in standard outlet box. Provide device capable of detecting series arcing current when the current to ground is 5 amperes or higher, and tripping per requirements of UL 1699.

2.15 PANELBOARDS

****

NOTE: For residential applications, use paragraph RESIDENTIAL LOAD CENTERS or LOAD CENTERS FOR HOUSING UNITS instead of PANELBOARDS unless required by the local Activity.

****

****

NOTE: For Navy projects, use the first bracketed paragraph. Select item m. below for unique applications involving non-standard frequencies or voltages.

Limit each panelboard to a maximum of 42 poles. Panelboards with up to 54 poles may be used in electrical renovations where the existing panelboards are replaced and wall space for additional panelboards is limited. Do not use dual section panelboards.

****

Provide panelboards in accordance with the following:

[a. UL 67 and UL 50 having a short-circuit current rating[as indicated][of 10,000 amperes symmetrical minimum for voltages 240 V and below] [of 14,000 amperes symmetrical minimum for 480 V].

b. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

c. Panelboards: circuit breaker-equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

f. Use of "Subfeed Breakers" is not acceptable.

g. Main breaker: "separately" mounted["above"][or]["below"] branch breakers.

h. Where "space only" is indicated, make provisions for future installation of breakers.

i. Directories: indicate load served by each circuit in panelboard.

j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

[k. Provide new directories for existing panels modified by this project as indicated.

] l.Type directories and mount in holder behind transparent protective covering.

[m. Panelboards: listed and labeled for their intended use.

] n. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

][a. UL 67 and UL 50.

b. Panelboards for use as service disconnecting: additionally conform to UL 869A.

c. Panelboards: circuit breaker-equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated.

f. Directories: indicate load served by each circuit of panelboard.

g. Directories: indicate source of service (e.g. upstream panel, switchboard, motor control center) to panelboard.

h. Type directories and mount in holder behind transparent protective covering.

i. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

]2.15.1 Enclosure

****
NOTE: For all outdoor applications at project locations with Environmental Severity Classification (ESC) factors of C4 and C5 and all indoor applications in a harsh environment, select NEMA 4X option below. In other outdoor locations, select NEMA 3R option. See UFC 1-200-01 for determination of ESC for project location. Designer to coordinate NEMA designation on drawings.
****

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: [hot-dipped galvanized after fabrication] [fiberglass enclosure].

c. Cabinets: painted in accordance with paragraph PAINTING.

d. Outdoor cabinets: [NEMA 3R raintight] [NEMA 4x] with[conduit hubs welded to the cabinet][a removable steel plate 7 mm 1/4 inch thick in the bottom for field drilling for conduit connections].

e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 3 mm 1/8 inch.

g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 15 mm 1/2 inch clear space between the back of the cabinet and the wall surface.

h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

i. Each door: fitted with a combined catch and lock latch.

j. Keys: two provided with each lock, with all locks keyed alike.

k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.15.2 Panelboard Buses

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. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding

conductors; bond to steel cabinet.[In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated.]

****

NOTE: Select the bracketed option below only if the non-linear loads are expected to be a majority of the downstream loads.

****

[2.15.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.

b. Panelboard: heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.

c. Verification of the testing procedure: provided upon request.

d. Two neutral assemblies paralleled together with cable is not acceptable.

e. Nameplates for panelboard rated for use on non-linear loads: marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.

f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

]2.15.3 Circuit Breakers

****

NOTE: For residential and BEQ/BOQ facility applications, use paragraph RESIDENTIAL LOAD CENTERS or LOAD CENTERS FOR HOUSING UNITS instead of PANELBOARDS unless panelboards with bolt-on breakers are required by the local Activity.

****

UL 489,[thermal magnetic-type][solid state-type] having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided.[Where indicated on the drawings, provide circuit breakers with shunt trip devices.] Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.15.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.15.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.15.3.3 Arc-Fault Circuit Interrupters

****
NOTE: NFPA 70 requires that all branch circuits that supply 120 volt, single phase, 15 and 20 ampere outlets installed in dwelling unit kitchens, laundry areas, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas and in dormitory units bedrooms, living rooms, hallways, closets, and similar rooms or areas are protected by an arc-fault circuit interrupter to provide protection of entire branch circuit.
****

****
NOTE: The one pole arc-fault circuit-interrupter is not designed for use on circuits in which the neutral conductor is shared with other circuits (defined as a multiwire branch circuit in NFPA 70) and will nuisance trip on shared neutral circuits. Provide and indicate on the drawings one pole arc-fault circuit-interrupter breakers for each circuit, and do not use shared neutral for these circuits in new construction projects. Where wiring is existing and not replaced and where a shared neutral exists, a two pole, 120/240 volt arc-fault circuit-interrupter for shared neutral circuits may be required. It may also be required in new construction if 120/240 volt equipment or circuit is located in the bedroom. Coordinate the requirement with the cognizant Activity.
****

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated.[Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable.] Provide with "push-to-test" button.

[2.15.4 Fusible Switches for Panelboards

NEMA KS 1, hinged door-type. Provide switches serving as motor disconnect means rated for kilowatt horsepower.

][2.15.5 400 Hz Panelboard and Breakers

Provide panelboards and breakers for use on 400 Hz systems rated and labeled "400 Hz."

][2.15.6 Branch Circuit Monitoring Panelboards

Provide a microprocessor-based panelboard monitoring system having the following features:

a. ANSI C12.1 and IEC 62053-21 Class 1 energy revenue metering accuracy.

b. Direct reading metered or calculated values for up to forty-two branch circuits.

c. Monitored values at the branch circuit level for current (A), power (kW), and energy (kWh).

d. Four user-configurable alarm thresholds.

e. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

][2.15.7 Lighting Control Panelboards

Provided a lighting control panelboard having the following features:

a. Minimum sixteen schedules including a 7-day repeating schedule with sixteen daily on/off periods.

b. Minimum sixteen lighting zones grouping branch breakers that are controlled by schedules, manual inputs, or override commands.

c. Electronic clock including real-time, astronomical clock, and leap year and daylight savings time adjustments.

d. Burn-hour tracking.

e. Remote circuit breaker operation.

[f. Master Lighting Control Panelboard with controller to control up to [8] [_____] control bussed located [individually][in slave panelboard] up to [400] [_____] feet away from the master panelboard.

] g. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

][2.16 RESIDENTIAL LOAD CENTERS

****

NOTE: Use the following paragraph and subparagraphs in lieu of the paragraph PANELBOARD and its subparagraphs if designer has chosen to specify residential load centers in the design. Load centers are permitted only for family housing construction/repair projects. Delete for other projects.

****

Provide residential load centers (RLCs) in accordance with the following:

a. UL 67 and UL 50.

b. RLCs for use as service disconnecting means: additionally conform to

UL 869A.

c. Circuit breaker equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. Where "space only" is indicated, make provisions for future installation of breakers sized as indicated.

[f. Provide load centers with keyed locks.

] g. Provide printed directories.

2.16.1 RLC Buses

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. Provide isolated groundable neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.16.2 Circuit Breakers

UL 489, thermal magnetic-type with interrupting capacity[as indicated][of 10,000 minimum amperes rms symmetrical]. Breaker terminals: UL listed as suitable for the type of conductor provided.

2.16.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Provide a breaker design such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any two adjacent breaker poles are connected to alternate phases in sequence.

[2.16.2.2 Circuit Breaker With Ground-Fault Circuit Interrupter

****
NOTE: Include for all locations required by NFPA 70.
****

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

]2.16.2.3 Arc-Fault Circuit-Interrupters

****
NOTE: NFPA 70 requires that all branch circuits that supply 120 volt, single phase, 15 and 20 ampere outlets installed in dwelling unit family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas are protected by

an arc-fault circuit interrupter to provide protection of entire branch circuit.
****

****
NOTE: The one pole arc-fault circuit-interrupter is not designed for use on circuits in which the neutral conductor is shared with other circuits (defined as a multiwire branch circuit in NFPA 70) and will nuisance trip on shared neutral circuits. Provide and indicate on the drawings one pole arc-fault circuit-interrupter breakers for each circuit, and do not use shared neutral for these circuits in new construction projects. Where wiring is existing and not replaced and where a shared neutral exists, a two pole, 120/240 volt arc-fault circuit-interrupter for shared neutral circuits may be required. It may also be required in new construction if 120/240 volt equipment or circuit is located in the bedroom. Coordinate the requirement with the cognizant Activity.
****

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated.[Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable.] Provide with "push-to-test" button.

][2.17 LOAD CENTERS FOR HOUSING UNITS

****
NOTE: UFC 3-520-01 allows load center style panelboards, with plug-in breakers, which can be used in housing units and BEQ/BOQ rooms.
****

Provide single-phase panelboards for housing units on this project in accordance with the following:

a. Load center type, circuit breaker equipped, conforming to UL 67 and UL 50.

b. Panelboards series short-circuit current rating: 22,000 amperes symmetrical minimum for the main breaker and the branch breakers.

c. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

f. Where "space only" is indicated, make provisions for future installation of breakers.

g. Provide cover with latching door.

h. Directories: indicate load served by each circuit in panelboard.

i. Directories: indicate source of service to panelboard (e.g., Panel PA served from panel MDP)

j. Type directories and mount behind in holder with transparent protective covering on inside of panel door.

2.17.1 Panelboard Buses

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. Provide copper or aluminum bus bars, either tin plated or silver plated. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.17.2 Circuit Breakers

UL 489 thermal magnetic type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Half-size and tandem breakers are not acceptable. Provide switch duty rated 15 and 20 ampere breakers. Breakers must not require use of panel trim to secure them to the bus.

2.17.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any two adjacent breaker poles are connected to Phases A and B respectively.

2.17.2.2 Arc-Fault Circuit-Interrupters

****

NOTE: NFPA 70 requires that all branch circuits that supply 120 volt, single phase, 15 and 20 ampere outlets installed in dwelling unit family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas are protected by an arc-fault circuit interrupter to provide protection of entire branch circuit.

****

****

NOTE: The one pole arc-fault circuit-interrupter is not designed for use on circuits in which the neutral conductor is shared with other circuits (defined as a multiwire branch circuit in NFPA 70) and will nuisance trip on shared neutral circuits. Provide and indicate on the drawings one pole arc-fault circuit-interrupter breakers for each circuit, and do not use shared neutral for these

circuits in new construction projects. Where wiring is existing and not replaced and where a shared neutral exists, a two pole, 120/240 volt arc-fault circuit-interrupter for shared neutral circuits may be required. It may also be required in new construction if 120/240 volt equipment or circuit is located in the bedroom. Coordinate the requirement with the cognizant Activity.

****

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated.[Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable.] Provide with "push-to-test" button.

]2.18 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated.[Provide solid neutral.]

[2.19 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

****

NOTE: MSCPs, also called motor circuit protectors (MCPs), are components of combination motor controllers rather than fuses or circuit breakers and are permitted if the motor short-circuit protector is part of a listed combination motor controller.

****

Motor short-circuit protectors, also called motor circuit protectors (MCPs): UL 508 and UL 489, and provided as shown. Provide MSCPs that consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. Rate MSCPs in accordance with the requirements of NFPA 70.

]2.20 TRANSFORMERS

****

NOTE: Coordinate the location of dry-type transformers with the mechanical designer to ensure adequate ventilation. This specification does not apply to transformers over 500 kVA, substation transformers, and transformers rated greater than 600 volts; for these types, see Section 26 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS, Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS, or Section 26 11 16 SECONDARY UNIT SUBSTATIONS for all projects; or Section 26 11 13.00 20 PRIMARY UNIT SUBSTATIONS for Navy projects; or Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION for Army projects. Specify 80 degrees C rise for dry-type transformers rated less than 15 kVA or 115 degrees C rise for

dry-type transformers rated 15 kVA or larger at a maximum ambient temperature of 40 degrees C. Delete quiet type where noise level does not affect personnel. Relative to noise: the least desirable location for the transformer is in a corner of a room, especially when there is a low ceiling.
****

****
NOTE: NEMA ST 20 is used below as a requirement for general purpose dry-type transformers. Although this document has been withdrawn by NEMA, it is still used as a requirement because manufacturers still use it as a design guide.
****

****
NOTE: Transformer taps may be Full Capacity Above Nominal (FCAN) which designates the transformer will deliver its rated kVA when connected to a voltage source which is higher than the rated primary voltage, or Full Capacity Below Nominal (FCBN) which designates the transformer will deliver its rated kVA when connected to a voltage source which is lower than the rated primary voltage. There may be taps plus/minus 2.5 percent or plus/minus 5 percent of the rated primary voltage and different numbers of taps FCAN and FCBN. Use available Cut Sheets or contact the transformer manufacturers to find out the required taps combinations.
****

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled,[ventilated][unventilated][sealed].

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

c. Taps for transformers 15 kVA and larger: [Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and four 2.5 percent taps Full Capacity Below Nominal (FCBN)] [Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and two 2.5 percent taps Full Capacity Below Nominal (FCBN)] [_____].

d. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding [115] [80] degrees C under full-rated load in maximum ambient of 40 degrees C.

(2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

[e. Transformer of 150 degrees C temperature rise is not acceptable.

][f. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation

rating.

][g. Transformer of 80 degrees C temperature rise: capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

][h. Transformers: quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

]2.20.1 Specified Transformer Efficiency

****

NOTE: Energy Star or energy efficient transformers are generally only available in ventilated enclosures.

****

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

[2.20.2 Transformers With Non-Linear Loads

****

NOTE: Complete an analysis of the connected loads to determine the harmonic contents and the appropriate K-Factor rating. K-Factor is defined as the sum from h=1 to infinity of $I_h(pu)^2h^2$ where I_h (pu) is the rms current at harmonic "h" (per unit of rated rms load current) and h is the harmonic order. Transformer K-factor ratings must be based on full-load conditions. K-Factor rated transformers ensure the transformer does not overheat and possibly fail. Use K-4 rating when connected loads are comprised of a large number of 100 percent non-linear single phase electronic equipment. Use K-13 rating when connected loads are comprised of single, large electronic loads, or small numbers of comparatively large single phase loads (i.e. mainframe computers or on-line UPS systems). Use caution in specifying K-ratings above K-13, as the impedance generally decreases as the K-ratings increase. Impedances below 3 percent are not recommended for computer loads connected to transformers with high K-ratings, as even higher neutral currents could result and possibly cause malfunctions or damage sensitive load equipment. Derated transformers also may be used to prevent overheating. Use harmonic mitigating transformer (HMT) if standard transformer has to be derated by more than 10 percent. HMT designed to greatly reduce certain harmonics based on their design, and thus reduce exposure to the rest of the electrical system from current harmonics drawn by downstream loads.

****

Provide transformers for non-linear loads in accordance with the following:

a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.

b. Transformers are to be UL listed and labeled for[K-4][K-9][K-13][K-Factor rating as indicated] in accordance with UL 1561.

c. Transformers evaluated by the UL K-Factor evaluation: listed for[115][80] degrees C average temperature rise only.

d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.

e. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

]2.21 MOTORS

****

NOTE: Motor and motor controller specifications must be thoroughly coordinated with and cross-referenced in all affected mechanical sections. Apply premium efficiency ratings per the Energy Policy Act of 2005 (EPACT 2005) to all motors. Specify Inverter-Rated motors that feature improved insulation systems for equipment with variable torque loads working with adjustable speed drive (ASD) (also referred to as variable frequency drive VFD) and specify Inverter-Duty motors for equipment with constant torque loads working with ASD per ASD manufacturer requirements including the manufacturer recommended cable type and length. Refer to NEMA MG-1.30. Use three-phase motors if more than 0.5 hp rating. If three-phase service is not available, operate motors larger than 0.5 hp at phase-to-phase voltage. Motors 0.5 hp and smaller should be single phase, with phase-to-phase voltage preferred over phase-to-neutral voltage.

****

Provide motors in accordance with the following:

a. NEMA MG 1[except provide fire pump motors as specified in Section 21 30 00] FIRE PUMPS.

b. Hermetic-type sealed motor compressors: Also comply with UL 984.

c. Provide the size in terms of kW HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.

d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.

e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.

f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.

g. Unless otherwise indicated, use continuous duty type motors if rated 746 Watts 1 HP and above.

h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

i. Use [Inverter-Rated] [Inverter-Duty] motors designed to operate with adjustable speed drive (ASD).

2.21.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.21.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.21.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.21.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment [using adjustable speed drive (ASD) manufacturer required wiring type and length] [, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to

equipment] as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.22 MOTOR CONTROLLERS

****

NOTE: Motor and motor controller specifications must be thoroughly coordinated with and cross-referenced in all affected mechanical sections. Indicate NEMA size of controller on mechanical drawings. Provide manual control capability for all installations having automatic control that operates the motor directly. Use a double-throw, three-position switch or other suitable device (marked MANUAL-OFF-AUTOMATIC) for the manual control. Confirm that all safety control devices, such as low-high-pressure cutouts, high-temperature cutouts, and motor overload protective devices, remain connected in the motor control circuit in both the manual and automatic positions. Provide motor controllers (starters) for motors larger than 0.125 horsepower and apply the design criteria of NEMA ICS 1 and NEMA ICS 2.

****

Provide motor controllers in accordance with the following:

a. UL 508, NEMA ICS 1, and NEMA ICS 2[, except fire pump controllers as specified in Section 21 30 00 FIRE PUMPS].

b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.

c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.

d. Provide protection for motors from immediate restart by a time adjustable restart relay.

e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.

f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.

g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.

h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.

[i. Provide selector switch with the means for locking in any position.

] j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.

l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.

[m. Minimum short circuit withstand rating of combination motor controller: [_____] rms symmetrical amperes.

][n. Provide controllers in hazardous locations with classifications as indicated.

]2.22.1 Control Wiring

Provide control wiring in accordance with the following:

a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.

b. Hinge wire: Class K stranding.

c. Current transformer secondary leads: not smaller than No. 10 AWG.

d. Control wire minimum size: No. 14 AWG.

e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.

f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.22.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

a. NEMA ICS 4.

b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.

c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.

d. Terminals: not less than No. 10 in size with sufficient length and

space for connecting at least two indented terminals for 10 AWG conductors to each terminal.

e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.

f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.

g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.22.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.22.3 Control Circuits

****
NOTE: Choose one of the following options.
****

[Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side.[Provide fuses in each ungrounded primary feeder]. Provide one fused secondary lead with the other lead grounded.[For designated systems, as indicated, provide backup power supply, including transformers connected to[emergency power source][_____]. Provide for automatic switchover and alarm upon failure of primary control circuit.]

][Control circuits: maximum voltage of 120 volts derived from a separate control source. Provide terminals and terminal boards. Provide separate control disconnect switch within controller. Provide one fused secondary lead with the other lead grounded.[For designated systems, as indicated, provide backup power supply, including connection to[emergency power

source][_____]. Provide for automatic switchover and alarm upon failure of primary control circuit.]

]2.22.4 Enclosures for Motor Controllers

****
NOTE: Indicate NEMA type of enclosure on the mechanical drawing to suit the application.
****

NEMA ICS 6.

2.22.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.22.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.22.7 Pilot and Indicating Lights

****
NOTE: Choose one of the following bracketed items. LED cluster lamps have an approximate life of 20,000 hours and will fit incandescent lamp bases. Incandescent lamps have an approximate life of 1,000 hours. LED colors are red, amber, yellow, and green and are not available in clear or white.
****

[Provide LED cluster lamps.][Provide transformer, resistor, or diode type.]

[2.22.8 Reduced-Voltage Controllers

****
NOTE: The designer determines, based on the power system characteristics, motor usage, and voltage drop where reduced-voltage controllers are necessary. See UFC 3-520-01 for additional information on selection and application.
****

Provide for polyphase motors [_____] kilowatt horsepower and larger. Reduced-voltage starters: single-step, closed transition[autotransformer,][reactor,][primary resistor-type,][solid state-type,] or as indicated, with an adjustable time interval between application of reduced and full voltages to motors.[Wye-delta reduced voltage starter or part winding increment starter having adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced-voltage starters for starting of[motor-generator sets,][centrifugally operated equipment,][or][reciprocating compressors provided with automatic unloaders].]

]2.23 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

[Single][Double][Three] pole designed for[flush][surface] mounting with overload protection[and pilot lights].

2.23.1 Pilot Lights

****
NOTE: Choose either the incandescent or LED bracketed sentence.
****

[Provide yoke-mounted, seven element LED cluster light module. Color:[green][red][amber][in accordance with NEMA ICS 2].][Provide yoke-mounted, candelabra-base sockets rated 125 volts and fitted with glass or plastic jewels. Provide clear, 6 watt lamp in each pilot switch. Jewels for use with switches controlling motors: green; jewels for other purposes:[white][red][amber].]

2.24 MOTOR CONTROL CENTERS

****
NOTE: Specify motor control center for groups of large motors requiring coordinated control. In other applications, individual controllers or motor control panelboards should be used. Generally, motor control centers should be NEMA, Class I, Type B. Coordinate controller specifications with the mechanical equipment requirements.

Class I motor control centers consist of mechanical groupings of combination motor-control units, feeder-tap units, other units and electrical devices arranged in a convenient assembly. Class II motor control centers are the same as Class I except with the addition of manufacturer-furnished electrical interlocking and wiring between units as specifically described by the designer on the construction drawings
****

Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Provide motor control centers in accordance with the following:

a. UL 845, NEMA ICS 2, NEMA ICS 3.

b. Wiring: Class[I][II], Type[A][B][C], in NEMA Type[1][3R][12][_____] enclosure.

c. Provide control centers suitable for operation on [_____]-volt, [_____]-phase, [_____]-wire, [_____] Hz system with minimum

short-circuit withstand and interrupting rating of[100,000][65,000][42,000][25,000][_____] amperes rms symmetrical.

d. Incoming power feeder: [bus duct][cable] entering at the[top][bottom] of enclosure and terminating on[terminal lugs][main protective device].

[e. Main protective device: [molded case circuit breaker][low-voltage power circuit breaker][fusible switch] rated at [_____] amperes rms symmetrical interrupting capacity.

][f. Arrange busing so that control center can be expanded from both ends.

] g. Interconnecting wires: copper.

h. Terminal blocks: plug-in-type so that controllers may be removed without disconnecting individual control wiring.

2.24.1 Bus Systems

Provide the following bus systems. Power bus: be braced to withstand fault current of[100,000][65,000][42,000][25,000][_____] amperes rms symmetrical. Wiring troughs: isolated from horizontal and vertical bus bars.

2.24.1.1 Horizontal and Main Buses

****

NOTE: 1,600-ampere, 2,000-ampere, and 2,500-ampere ratings are also available. However, equipment at those ratings may not be UL listed and have not been included as an option.

****

Horizontal bus: continuous current rating of[600][800][1000][1200][_____] amperes. Main bus: [aluminum, tin-plated][copper, silver-plated] enclosed in isolated compartment at top of each vertical section. Main bus: isolated from wire troughs, starters, and other areas.

2.24.1.2 Vertical Bus

****

NOTE: Select from the bracketed options below. Higher ratings might be available; however, equipment at those ratings may not be UL listed and have not been included as an option.

****

Vertical bus: continuous current rating of[300][450][600][_____] amperes, and [aluminum, tin-plated][copper, tin-plated][copper, silver-plated]. Vertical bus: enclosed in flame-retardant, polyester glass "sandwich."

2.24.1.3 Ground Bus

Copper ground bus: provided full width of motor control center and equipped with necessary lugs.

[2.24.1.4 Neutral Bus

Insulated neutral bus: provided continuous through the motor control center; neutral full rated. Provide lugs of appropriate capacity, as required.

][2.24.2 Combination Motor Controllers

****
NOTE: Select Combination Motor Controllers if required by project documents. Select options below and include short circuit rating requirement.
****

UL 508 and other requirements in paragraph, MOTOR CONTROLLERS. Provide in controller a[molded case circuit breaker][fusible switch with clips for [_____]-type fuses for branch circuit protection].[Minimum short circuit withstand rating of combination motor controller: [_____] rms symmetrical amperes.][Circuit breakers for combination controllers: [thermal magnetic][magnetic only].]

][2.24.3 Space Heaters

****
NOTE: Heaters should be connected to an external power source in installations where the motor control center will not be energized continuously.
****

Provide space heaters where indicated on the drawings, controlled using an adjustable 10 to 35 degrees C 50 to 90 degrees F thermostat, magnetic contactor, and a molded-case circuit breaker[and a 480-120 volt single-phase transformer]. Provide space heaters equipped with 250-watt, 240 volt strip elements operated at 120 volts and[supplied from the motor control center bus][wired to terminal blocks for connection to 120-volt single-phase power sources located external to the control centers]. Contactors: open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

]2.25 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.26 TELECOMMUNICATIONS SYSTEM

****
NOTE: This paragraph provides information related to telecommunications system requirements for pathway and electrical service. Complete system cabling and interconnecting hardware are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM, and Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Where Section 27 10 00 is not provided and an empty

conduit system is required for telecommunications service, copy and paste the subparagraph BACKBOARDS under the major paragraph COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM as a subparagraph to this paragraph.
****

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires[wireways,][cable trays,] and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein.[Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.]

[2.27 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

****
NOTE: 1. Use paragraph CATV OUTLETS and CATV FACEPLATES for empty conduit systems only, where cable is not provided in the project.

2. Designer: provide riser diagram of system on drawings and provide empty conduit to exterior location for CATV service entrance.

3. Use Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM where complete CATV system is provided. Delete paragraphs CATV OUTLETS and CATV FACEPLATES when Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM is used on the project.
****

[Additional CATV requirements are specified in Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM.

][2.27.1 CATV Outlets

Provide flush mounted, 75-ohm, F-type connector outlet rated from 5 to 1000 MHz in standard electrical outlet boxes[with isolation barrier] with mounting frame.

][2.27.2 CATV Faceplates

Provide modular faceplates for mounting of CATV Outlets.[Faceplate: include designation labels and label covers for circuit identification.] Faceplate color: match outlet and switch coverplates.

][2.27.3 Backboards

****
NOTE: Choose the first bracketed sentence when providing an empty conduit system or choose the second bracketed sentence when Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM is used. When using "as indicated" option, ensure information required is shown on the drawings.
****

[Provide void-free, fire rated interior grade plywood, 19 mm 3/4 inch

thick, [1200 by 2400 mm] [4 by 8 feet][as indicated]. Do not cover the fire stamp on the backboard.][Coordinate CATV backboard requirements with telecommunications backboard requirements as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING.]

]]2.28 GROUNDING AND BONDING EQUIPMENT

****
NOTE: Select ground rod type. Most applications will only need copper-clad steel.

In high resistivity soils, 3000 mm 10 foot sectional rods may be used to obtain the required resistance to ground; however, where rock is encountered, additional rods, a ground ring electrode, or ground grid may be necessary. Coordinate and standardize rod selection for individual facilities with other specification sections.
****

2.28.1 Ground Rods

UL 467. Ground rods: cone pointed[copper-clad steel][solid copper][stainless steel], with minimum diameter of 19 mm 3/4 inch and minimum length [of 3050 mm][of 6100 mm] 10 feet. Sectional ground rods are permitted.

[2.28.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

]2.28.3 Telecommunications [and CATV]Grounding Busbar

****
NOTE: 1. Minimum width for the telecommunications main grounding busbar (TMGB) is 100 mm 4 in and for the telecommunications grounding busbar (TGB) is 50 mm 2 in. Telecommunications grounding busbar provides grounding termination for voice, data and video (CATV) systems.

2. Choose the bracketed option for Telecommunication Grounding Busbars (TGB) when there are more than one telecommunications room or telecommunications equipment rooms included in the project.
****

Provide corrosion-resistant grounding busbar suitable for[indoor][outdoor] installation in accordance with TIA-607. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility[and a (TGB) in all other telecommunications rooms and equipment rooms]. The telecommunications main grounding busbar (TMGB)[and the telecommunications grounding busbar (TGB)]: sized in accordance with the immediate application requirements

and with consideration of future growth. Provide telecommunications grounding busbars with the following:

a. Predrilled copper busbar provided with holes for use with standard sized lugs,

b. Minimum dimensions of 6 mm 0.25 in thick by 100 mm 4 in wide for the TMGB[and 50 mm 2 in wide for TGBs] with length as indicated;

c. Listed by a nationally recognized testing laboratory.

[2.29 HAZARDOUS LOCATIONS

****
NOTE: Indicate very clearly the limits of all hazardous locations. Edit the last sentence for actual equipment required in hazardous locations.
****

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by NFPA 70: specifically approved by Underwriters' Laboratories, Inc., or Factory Mutual for particular "Class," "Division," and "Group" of hazardous locations involved. Boundaries and classifications of hazardous locations: as indicated. Equipment in hazardous locations: comply with UL 1203 for electrical equipment and industrial controls and UL 674 for motors.

]2.30 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment 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 will not be acceptable.

2.31 FIELD FABRICATED NAMEPLATES

****
NOTE: Use the following paragraph where nameplates are fabricated to identify specific equipment designated on the drawings. Provide note on panelboard schedules to indicate where red labels are required.
****

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 3 mm 0.125 inch thick, white with [black] [_____] center core.

[e. Provide red laminated plastic label with white center core where

indicated.

] f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

g. Minimum size of nameplates: 25 by 65 mm one by 2.5 inches.

h. Lettering size and style: a minimum of 6.35 mm 0.25 inch high normal block style.

2.32 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.33 FIRESTOPPING MATERIALS

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

2.34 WIREWAYS

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.

[2.35 METERING

****

NOTE: Include "metering" information when a single-phase self contained meter base is required. Coordinate with Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMER and Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Add appropriate verbiage to identify the exterior equipment (such as metering, supports, and disconnect switches) that would then be covered by this section. When a three-phase service is designed, modify meter requirements accordingly.

For the Air Force, delete this option and use Section 26 27 13.10 30 ELECTRIC METERS.

For the Navy, delete this option and use Section 26 27 14.00 20 ELECTRICITY 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. Coordinate meter, system components, and meter location to be compatible with the Activity's central advanced metering system.

****
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.

][2.36 METER BASE ONLY

****
NOTE: Use METER BASE ONLY paragraph for projects where meters are not currently required, but may be required in the future, for example, military housing units.
****

ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having jaws compatible with requirements of a class: 200 and Form: [2S][_____] self contained watthour meter. Provide gray plastic closing cover and bypass links. Provide manufacturers standard enclosure color unless otherwise indicated.

]2.37 SURGE PROTECTIVE DEVICES

****
NOTE: Surge protection should be provided for the following types of facilities: Medical facilities;

Air navigation aids and facilities; Petroleum, oil and lubricant (POL) storage and dispensing facilities; Critical utility plants and systems; Communication facilities and telephone exchanges; Fire stations, including fire alarm, fire control and radio equipment; Critical computer automatic data processing facilities; Air traffic control facilities; Base weather stations; Surveillance and warning facilities; Photovoltaic system Solar Arrays (refer to NFPA 70 and NFPA 780); Command and control facilities; Weapon systems; Security lighting systems; Mission, property and life support facilities at remote and not readily accessible sites.

Consider surge protection for all types of facilities located in regions with a high lightning strike probability (refer to IEEE C62.41.1 and C62.41.2) and facilities located near commercial utility systems with routine substation capacitor switching. The IEEE Emerald book recommended practice is that SPDs be applied to service entrance electrical switchboards and panelboards, and panelboards located on the secondary of separate derived systems that support ITE, telephone, telecommunications, signaling, television, or other form of electronic load equipment.

There are 3 types of surge protective devices (SPDs):

1. Type 1 SPDs are line side permanently installed, hard-wired surge protectors which are permitted to be connected to the supply side of the service disconnect following NFPA 70 requirements, and as specified for Type 2 SPDs.

2. Type 2 SPDs are load side permanently installed, hard-wired surge protectors which are permitted to be connected on the load side of a dedicated circuit breaker of the associated main distribution or branch panelboard, switchboard, or switchgear.

3. Type 3 SPDs are load side point-of-use (plug-in type) surge protectors which are protected specific critical equipment that plugs into receptacles. Type 3 SPD may be an integral component of a receptacle. UFC 3-520-01 does not apply to Type 3 SPDs.

Refer to UFC 3-520-01 for additional criteria.

****

****

NOTE: Whenever possible, connect surge protectors to a spare circuit breaker in the associated panel. Locate the surge protectors immediately adjacent to the protected equipment. Do not allow SPD inside a panelboard or switchboard enclosure due to fire risk causing loss of power to entire panelboard or switchboard. Do not allow fuses integral to SPDs

due to lack of repetitive capability to protect from surges.

It is not necessary to provide surge protection on all panelboards; the selection of which panelboards should have surge protective devices depends on the importance of the loads served and the sensitivity of electronic equipment connected to the circuits.

Switching loads such as motor control centers should have surge protection to limit the transmission of switching transients to the rest of the facility.

HVAC equipment usually contain electronic controls that are sensitive to surges.

****

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. SPD must have the same short-circuit current rating as the protected equipment and shall not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

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, and N-G Voltage Protection Rating:

[600V for 120V, single phase system]

[1,000V for 120/240V, single phase system]
[600V for 120/240V, three phase system]
[600V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-G Protection Rating:
[700V for 120V, single phase system]
[1,000V for 120/240V, single phase system]
[700V for 120/240V, three 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 120/240V, three phase system]
[1,200V for 208Y/120V, three phase system]
[1,800V 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 percent of nominal voltage for 240 volts and below; 115 percent 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.

]2.38 FACTORY APPLIED FINISH

****
NOTE: This paragraph covers only the basic painting requirements for most electrical equipment. Include any special finishes for high or low temperatures and corrosive atmospheres.
****

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 PAINTING.

2.39 SOURCE QUALITY CONTROL

2.39.1 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.

[2.40 COORDINATED POWER SYSTEM PROTECTION

****

NOTE: Do not use on Navy projects.

NOTE: The requirement for studies in this paragraph depends on the complexity and extent of the power system. Delete this requirement for projects of limited scope, projects having protective devices which are not adjustable or for which coordination is not possible (standard molded case circuit breakers); projects involving simple extension of 600 volt level service to a building or facility from an existing transformer (750 kVA or less); or projects involving simple extension of 600 volt level service to a building or facility from a new transformer (750 kVA or less).

****

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

]PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

[3.1.1 Underground Service

****
NOTE: Choose this paragraph or the paragraph, OVERHEAD SERVICE. When using this paragraph, designer may insert additional details describing the specific project.
****

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

][3.1.2 Overhead Service

****
NOTE: Use Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION for overhead service requirements (typical throughout this section).
****

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.]

][3.1.3 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.

]3.1.4 Service Entrance Identification

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

3.1.4.1 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.

3.1.5 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.

3.1.5.1 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.

[3.1.5.2 Metal-Clad Cable

****
NOTE: Type MC cable is UL listed; NFPA 70 is recognized for most common building applications. MC cable does not protect conductors as well as rigid conduit but is more flexible to install and relocate. Refer to PART 2 PRODUCTS paragraph METAL-CLAD CABLE for UFC 3-520-01 requirements.
****

Install in accordance with NFPA 70, Type MC cable.

][3.1.5.3 Armored Cable

****
NOTE: Type AC cable has more restricted applications than MC cable but offers the same advantages. Review NFPA 70 and refer to PART 2 PRODUCTS paragraph ARMORED CABLE for UFC 3-520-01 requirements.
****

Install in accordance with NFPA 70, Type AC cable.

][3.1.5.4 Flat Conductor Cable

****
NOTE: Type FCC cable has been listed by UL and recognized by NFPA 70 for under carpet tile applications. FCC cable is available off the shelf for power, and telecommunications transmission applications.
****

Install in accordance with NFPA 70, Type FCC cable.

]3.1.6 Conduit Installation

****
NOTE: Where exposed conduit is installed and subject to vandalism or misuse, such as in toilet or locker rooms, do not allow perpendicular or right angle to ceiling structural members. Provide details on drawings to identify special treatments or offsets as needed.

****

****

NOTE: Do not install exposed conduit systems in inmate housing areas and other areas normally accessible to inmates unless such installations are specifically indicated. Where exposed conduit is indicated, provide rigid metallic type conduit and cast metal-type outlet boxes with threaded hubs. Install conduits flat against wall; offsets or "kicks" are permitted only to enter outlet box. Support conduits on 1525 mm 5 foot maximum centers and within 305 mm 12 inches of each outlet box using two-hole conduit straps attached to surface with nonremovable break off security type bolts.

****

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.]

3.1.6.1 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.

b. Do not use brass or bronze fittings.

c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.2 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

[3.1.6.3 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not

limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

b. PVC Schedule 40 and Schedule 80.

(1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

-

]3.1.6.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.5 Underground Conduit

****

NOTE: Soil conditions in some locations require that underground conduit be supported to prevent damage due to settlement. The designer determines if the problem exists, and, if so, determines the best method for supporting the 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.

[3.1.6.6 Conduit Interior to Buildings for 400 Hz Circuits

Aluminum or nonmetallic. Where 400-Hz circuit runs underground or through concrete, provide PVC Schedule[40][80] conduit.

]3.1.6.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.6.8 Conduit Installed Under Floor Slabs

****

NOTE: Designer must closely coordinate with the design of building floor slab and soil conditions and evaluate the acceptability of conduit being installed directly beneath the floor slab. Consider whether it will be necessary to support conduit in case of soil settlement problems and vapor barrier penetrations. Provide details on the drawings to clarify specification.

****

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.

3.1.6.9 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

[3.1.6.10 Conduit Installed in Concrete Floor Slabs

****

NOTE: When this option is included, (such as in BEQ's and similar projects with precast planks and topping slabs), indicate specific locations and provide installation details on the electrical drawings. Electrical designer must closely coordinate this information with the designer of the slab to ensure that slab thickness, conduit placement/separation, and reinforcement spacing is sufficient to meet requirements of this paragraph. Do not specify metal conduit in concrete that contains coral aggregate or is made with salt or brackish water. This type of concrete is rarely allowed.

For Navy projects, use second bracketed option, limiting conduit type to PVC EPC-40, unless required otherwise for medical facilities.

****

[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 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.]

]3.1.6.11 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.

3.1.6.12 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.

3.1.6.13 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.

3.1.6.14 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.6.15 Flexible Connections

****

NOTE: For Navy projects, do not use flexible nonmetallic conduit.

****

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 liquid tight 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.

3.1.6.16 Telecommunications and Signal System Pathway

****

NOTE: For guidelines on conduit sizing, see UFC 3-580-01, "Telecommunications Building Cabling System Planning, Design" and NFPA 70.

****

Install telecommunications pathway in accordance with TIA-569.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568-C.1. Size conduits[, wireways][, and cable trays] in accordance with TIA-569[and][as indicated].

b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with TIA-569. Size conduits[, wireways][, and cable trays] for telecommunications risers in accordance with TIA-569[and][as indicated].

[3.1.6.17 Community Antenna Television (CATV) System Conduits

****

NOTE: Choose the bracketed item depending on the CATV system design. Delete this paragraph if an empty conduit CATV system is not used.

****

Install a system of CATV wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires[wireways,][cable trays,] and other accessories for CATV outlets and pathway in accordance with TIA-569. [Provide distribution system with star topology with empty conduit and pullwire from each outlet box to the telecommunications room and empty conduit and pullwire from each telecommunications room to the headend equipment location][Provide distribution system with star topology with empty conduit and pullwire from each outlet to the headend equipment location].

]3.1.7 Busway Installation

Comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 1525 mm 5 foot maximum intervals, and brace to prevent lateral movement. Provide fixed type hinges on risers; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam

and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. 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.

3.1.8 Cable Tray Installation

****
NOTE: For Navy projects, use the second bracketed paragraph. Include bracketed second sentence where cable tray is used for telecommunications system.
****

[Install and ground in accordance with NFPA 70.[In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607]. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support[in accordance with manufacturer recommendations but at not more than [1830] [_____] mm [6] [_____] foot intervals][as indicated].[Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly.] Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 255 mm 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 103 mm 4 inch rigid steel conduits with grounding bushings, extending 305 mm 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. 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.

][Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support[as indicated][at maximum [1830] [_____] mm [6] [_____] foot] intervals.[In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607][Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly.] Ensure edges, fittings, and hardware are finished free from burrs and sharp edges. Provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section. Use No. 1/0 aluminum wire if cable tray is aluminum. Install conductors that run though smoke and fire partitions in 103 mm 4 inch rigid steel conduits with grounding bushing, extending 305 mm 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. 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.

][3.1.9 Telecommunications Cable Support Installation

****
NOTE: Utilize open telecommunications cable supports (J-Hooks / J-Supports / D-rings) only as specifically permitted in UFC 3-580-01, Telecommunications, Building Cabling System.
****

Install open top and closed ring cable supports on 1.2 m 4 ft to 1.5 m 5 ft

centers to adequately support and distribute the cable's weight. Use these types of supports to support a maximum of 50 6.4 mm 0.25 in diameter cables. Install suspended cables with at least 75 mm 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

]3.1.10 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces,[when surface mounted on interior walls exposed up to 2135 mm 7 feet above floors and walkways,][or when installed in hazardous areas] and when specifically indicated. Boxes in other locations: sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic[sheathed cable] conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 100 mm 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel.[Threaded studs driven in by powder charge and provided with lock washers and nuts[or nail-type nylon anchors] may be used in lieu of wood screws, expansion shields, or machine screws.] In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 610 mm 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.10.1 Boxes

Boxes for use with raceway systems: minimum 40 mm 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 100 mm 4 inches square, except that 100 by 50 mm 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets: a minimum of [100 mm square by 54 mm deep][120 mm square by 54 mm deep] [4 inches square by 2 1/8 inches deep][4 11/16 inches square by 2 1/8 inches deep][, except for [wall mounted telephones] [and] [outlet boxes for handicap telephone stations]]. Mount outlet boxes flush in finished walls.

3.1.10.2 Pull Boxes

Construct of at least minimum size required by NFPA 70[of code-gauge

aluminum or galvanized sheet steel,][and][compatible with nonmetallic raceway systems,] except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

[3.1.10.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

]3.1.11 Mounting Heights

****

NOTE: In Hazardous Areas extending up to 455 mm 18 inches above the finished floor, the mounting height of receptacles that are not explosion-proof, must be measured to the bottom of the outlet box in lieu of to the center. Coordinate the mounting height with the height indicated on the drawings and use the last bracketed sentence.

****

Mount panelboards,[enclosed] circuit breakers,[motor controller] and disconnecting switches so height of operating handle at its highest position is maximum 1980 mm 78 inches above floor. Mount lighting switches[and handicapped telecommunications stations][1220 mm 48 inches above finished floor]. Mount receptacles[and telecommunications outlets] 460 mm 18 inches above finished floor[, unless otherwise indicated].[Wall-mounted telecommunications outlets: mounted at height[1525 mm 60 inches above finished floor][indicated].] [Mount other devices as indicated.][Measure mounting heights of wiring devices and outlets[in non-hazardous areas]to center of device or outlet.][Measure mounting heights of receptacle outlet boxes in the[hazardous area][_____] to the bottom of the outlet box.]

[3.1.12 Nonmetallic Sheathed Cable Installation

****

NOTE: Use this paragraph only when Type NM or NMC cable is indicated.

****

Where possible, install cables concealed behind ceiling or wall finish. Thread cables through holes bored on approximate centerline of wood members; notching of end surfaces is not permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel to or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 1220 mm 4 feet above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in studs at each point through which cable passes, prior to installation of cable.

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

****

NOTE: Type MI cable used for low temperature, high temperature, hazardous locations, life safety, and

heating applications. Refer to NFPA 70. Clearly show on drawings the MI cable. Consider surge suppressors in hazardous locations and where high voltage surges are likely. MI cable is not available in ratings above 600 volts.
****

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.

]3.1.14 Conductor Identification

****
NOTE: Reference the section providing details of identifying control circuit wiring. Use Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS for Navy projects only.
****

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.]

3.1.14.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables 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.

3.1.15 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.15.1 Splices of Aluminum Conductors

Make with solderless circumferential compression-type, aluminum-bodied connectors UL listed for AL/CU. Remove surface oxides from aluminum conductors by wire brushing and immediately apply oxide-inhibiting joint compound and insert in connector. After joint is made, wipe away excess joint compound, and insulate splice.

[3.1.16 Terminating Aluminum Conductors

3.1.16.1 Termination to Copper Bus

Terminate aluminum conductors to copper bus either by: (a) inline splicing a copper pigtail, of ampacity at least that of aluminum conductor, or (b) utilizing circumferential, compression-type, aluminum-bodied terminal lug UL listed for AL/CU, and steel Belleville cadmium-plated hardened steel spring washers, flat washers, bolts, and nuts. Carefully install Belleville spring washers with crown up toward nut or bolt head, with concave side of Belleville bearing on heavy-duty, wide series flat washer of larger diameter than Belleville. Tighten nuts sufficiently to flatten Belleville, and leave in position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

3.1.16.2 Termination to Aluminum Bus

Terminate aluminum conductors to aluminum bus by using aluminum nuts, bolts, washers, and compression lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection. When bus contact surface is unplated, scratch-brush and coat with joint compound, without grit.

]3.1.17 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.

3.1.18 Electrical Penetrations

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

3.1.19 Grounding and Bonding

****
NOTE: Use reference to NFPA 780 and last bracketed sentence where lightning protection is provided. In addition, size and indicate the grounding electrode conductor in accordance with NFPA 780. Coordinate requirements with Section 26 41 00 LIGHTNING PROTECTION SYSTEM.
****

Provide in accordance with NFPA 70[and NFPA 780]. Ground exposed, non-current-carrying metallic parts of electrical equipment,[access flooring support system,] metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, [grounding conductor of nonmetallic sheathed cables,]and neutral conductor of wiring systems.[Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70.][Make ground connection to driven ground rods on exterior of building. Bond additional driven rods together with a minimum of 4 AWG soft bare copper wire buried to a depth of at least 300 mm 12 inches.][Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system.] In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.19.1 Ground Rods

****
NOTE: Do not use chemically charged ground rods without authorization of the local Activity.
****

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, [_____] additional rods, spaced on center. Spacing for additional rods must be a minimum of 3 meters 10 feet[, or if sectional type rods are used, [_____] additional sections may be coupled and driven with the first rod].[In high-ground-resistance, UL listed chemically charged ground rods may be used.] If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on

the number of ground rods to add.

3.1.19.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible,[excepting specifically those connections for which access for periodic testing is required,] by exothermic weld or high compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.19.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of[transformer neutrals and other electrical][electrical] equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment.[For raised floor equipment rooms in computer and data processing centers, provide a minimum of four, one at each corner, ground buses connected to the building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and alterations.]

3.1.19.4 Resistance

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NOTE: If difficulties are encountered in obtaining the proper resistance, the Contracting Officer will make a decision on the number of ground rods to be used, based on local conditions and on the type and size of electrical installation in the project. Insulated grounding conductors will be required where electrolytic corrosion may be encountered. In most applications, it is desirable to have a maximum resistance of much less, typically 5 ohms or less. NFPA 70, approves the use of a single made electrode for the system-grounding electrode, if its resistance does not exceed 25 ohms.

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Maximum resistance-to-ground of grounding system: do not exceed[5] [_____] ohms under dry conditions. Where resistance obtained exceeds[5] [_____] ohms, contact Contracting Officer for further instructions.

3.1.19.5 Telecommunications System

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NOTE: 1. Include this paragraph when telecommunications service is provided in job and specified in this section and other sections.

2. Choose the bracketed option for Telecommunication Grounding Busbars (TGB) when there are more than one telecommunications room or telecommunications equipment rooms included in the project.

3. Choose Telecommunications Bonding Conductors bracketed option when more than one telecommunications grounding busbar is installed as part of the project.

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Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. Install the TMGB as close to the electrical service entrance grounding connection as practicable.[Provide a telecommunications grounding busbar (TGB) in all other telecommunications rooms and telecommunications equipment rooms. Install the TGB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the TGB near the backbone cabling and associated terminations. In addition, locate the TGB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a TGB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the TGB.] Install telecommunications grounding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 50 mm 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the TMGB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds one m3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum.[Provide a telecommunications bonding backbone (TBB) that originates at the TMGB extends throughout the building using the telecommunications backbone pathways, and connects to the TGBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a TGB continuous. Where splices are necessary, the number of splices should be a minimum.

Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the TMGB or the TGB.]

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the TMGB[or TGB]: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the TMGB[or TGB] to the TMGB[or TGB respectively]. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each TMGB[and TGB] to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the TGB or TMGB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the TGB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.20 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.21 Elevator

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NOTE: To achieve a complete specification, the ensure that the controls for HVAC, fire alarm system, elevators, cranes, and special systems are definitely and properly covered by the other sections of the project specification. Should controls appear in this section of the project specification, modify this paragraph accordingly. Indicate on the drawings required equipment connections. Coordinate elevator paragraph with Section 14 21 13 ELECTRIC TRACTION FREIGHT ELEVATORS or Section 14 21 23 ELECTRIC TRACTION PASSENGER ELEVATORS and Section 14 24 13 HYDRAULIC FREIGHT ELEVATORS or 14 24 23 HYDRAULIC PASSENGER ELEVATORS for all projects. Where more than one driving machine disconnecting means is supplied by a single feeder, the overcurrent protective devices in each disconnecting means must be selectively coordinated with any other supply side overcurrent protective devices.

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Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

[3.1.22 Government-Furnished Equipment

Contractor[rough-in for Government-furnished equipment][make connections to Government-furnished equipment] to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

]3.1.23 Repair of Existing Work

Perform repair of existing work[, demolition, and modification of existing electrical distribution systems] as follows:

3.1.23.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.23.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

[3.1.23.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings,[back to equipment's power source] as indicated.

][3.1.23.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

][3.1.24 Watthour Meters

ANSI C12.1.

]3.1.25 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 avoiding 90 degree bends.

3.2 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.

3.3 WARNING SIGN MOUNTING

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

3.4 FIELD APPLIED PAINTING

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NOTE: Use and coordinate paint and coating requirements with Section 09 90 00 PAINTS AND COATINGS when provided in the job. Use the second bracketed option when Section 09 90 00 is not provided or when requirements are beyond what is specified in Section 09 90 00.

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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.]

3.5 FIELD QUALITY CONTROL

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NOTE: Provide any additional test requirements for equipment requiring running tests or tests that must be coordinated with mechanical equipment.

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Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer[5] [_____] working days notice prior to[each] [_____] test[s].

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test 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 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused shall also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, 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.

3.5.4 Ground-Fault Receptacle Test

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NOTE: If Ground-Fault Receptacle "line" and "load" leads are reversed, "test" will trip downstream loads but not trip the receptacle.

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Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

3.5.5 Arc-Fault Receptacle Test

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NOTE: If Arc-Fault Receptacle "line" and "load" leads are reversed, "test" will trip downstream loads but not trip the receptacle.

****

Test arc-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 1699.

3.5.6 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

[3.5.7 Watthour Meter

a. Visual and mechanical inspection

   (1) Examine for broken parts, shipping damage, and tightness of connections.

   (2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

   (1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

]3.5.8 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

-- End of Section --