
USACE / NAVFAC / AFCEA / NASA UFGS-26 20 00 (July 2007)

Preparing Activity: NAVFAC Replacing without change
UFGS-16402 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2008

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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 33 71 02.00 20, UNDERGROUND TRANSMISSION AND DISTRIBUTION; L-16303N, UNDERGROUND ELECTRICAL WORK; Section 26 11 13, SECONDARY UNIT SUBSTATIONS; and Section 26 12 19.10, PAD-MOUNTED TRANSFORMERS for Navy projects and Section 33 71 01, ELECTRICAL DISTRIBUTION SYSTEM, AERIAL; Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; and Section 26 11 14.00 10, MAIN ELECTRIC SUPPLY STATION AND SUBSTATION on Army projects as required. Requirements for materials and procedures for special or unusual design should be added as necessary to fit specific projects.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

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

NOTE: The following information shall be 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 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 in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.7 (2005) Requirements for Watthour Meter Sockets

ASTM INTERNATIONAL (ASTM)

ASTM B 1 (2001; R 2007) Standard Specification for Hard-Drawn Copper Wire

ASTM B 8 (2004) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D 709 (2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2007) National Electrical Safety Code
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1) Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2005) General Instructions for Proper Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less
NEMA C12.1	(2001) Electric Meters; Code for Electricity Metering
NEMA C80.1	(2005) Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA C80.3	(2005) Standard for Electrical Metallic Tubing (EMT)
NEMA C80.5	(2005) Standard for Electrical Rigid Aluminum Conduit (ERAC)
NEMA FU 1	(2002) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005) Standard for Industrial Control and Systems General Requirements
NEMA ICS 2	(2000; Errata 2002; R 2005; Errata 2006) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 3	(2005) Standard for Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
NEMA ICS 4	(2005) Industrial Control and Systems: Terminal Blocks

NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA KS 1	(2001; R 2006) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
NEMA MG 1	(2006; Errata 2007) Standard for Motors and Generators
NEMA MG 10	(2001; R 2007) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005) Standard for Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride PVC Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers
NEMA VE 1	(2002) Standard for Metallic Cable Tray Systems
NEMA WD 1	(1999; R 2005) Standard for General Requirements for Wiring Devices
NEMA WD 6	(2002) Standard for Wiring Devices - Dimensional Requirements
NEMA Z535.4	(2007; Errata 2007) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code
NFPA 70E	(2004; AMD 2004) Electrical Safety in the Workplace

NFPA 780 (2007) Standard for the Installation of
Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607-A (2002) Commercial Building Grounding
(Earthing) and Bonding Requirements for
Telecommunications

TIA/EIA-568-B.1 (2001 Addendums 2001, 2003, 2003, 2003,
2004, 2007) Commercial Building
Telecommunications Cabling Standard - Part
1: General Requirements

TIA/EIA-569-A (1998; Addenda 2000, 2001) Commercial
Building Standards for Telecommunications
Pathways and Spaces

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

29 CFR 1910.147 Control of Hazardous Energy (Lock Out/Tag
Out)

UNDERWRITERS LABORATORIES (UL)

UL 1 (2005; Rev thru Jul 2007) Standard for
Flexible Metal Conduit

UL 1010 (2006) Receptacle-Plug Combinations for
Use in Hazardous (Classified) Locations

UL 1063 (2006) Standard for Safety Machine-Tools
Wires and Cables

UL 1242 (2006; Rev thru Jul 2007) Standard for
Electrical Intermediate Metal Conduit --
Steel

UL 1449 (2006) Surge Protective Devices

UL 1561 (1999; Rev thru Sep 2005) Dry-Type General
Purpose and Power Transformers

UL 1569 (1999; Rev thru Nov 2006) Metal-Clad Cables

UL 1660 (2004; Rev thru Jan 2005) Liquid-Tight
Flexible Nonmetallic Conduit

UL 1699 (1999; Rev thru May 2003) Arc-Fault
Circuit-Interrupters

UL 198M (2003) Mine-Duty Fuses

UL 20 (2000 ; Rev thru Dec 2004) Standard for
General-Use Snap Switches

UL 2043 (1996; Rev thru Jun 2001) Fire Test for
Heat and Visible Smoke Release for
Discrete Products and Their Accessories

Installed in Air-Handling Spaces

UL 360	(2003; Rev thru Jul 2007) Liquid-Tight Flexible Steel Conduit
UL 4	(2004) Armored Cable
UL 44	(2005; Rev thru Nov 2005) Thermoset-Insulated Wires and Cables
UL 467	(2007) Standard for Grounding and Bonding Equipment
UL 486A-486B	(2003; Rev thru Aug 2006) Standard for Wire Connectors
UL 486C	(2004; Rev thru Aug 2006) Standard for Splicing Wire Connectors
UL 489	(2002; Rev thru Jun 2006) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2001; Rev thru May 2007) Attachment Plugs and Receptacles
UL 5	(2004; Rev thru May 2007) Surface Metal Raceways and Fittings
UL 50	(2007) Standard for Enclosures for Electrical Equipment
UL 506	(2000; Rev thru May 2006) Standard for Specialty Transformers
UL 508	(1999; Rev thru Jul 2005) Standard for Industrial Control Equipment
UL 510	(2005; Rev thru Aug 2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 512	(1993; Rev thru Mar 1999) Fuseholders
UL 514A	(2004; Rev thru Aug 2007) Standard for Metallic Outlet Boxes
UL 514B	(2004; Rev thru Aug 2007) Standard for Conduit, Tubing and Cable Fittings
UL 514C	(1996; Rev thru Mar 2007) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 5A	(2003) Nonmetallic Surface Raceways and Fittings
UL 6	(2004) Standard for Electrical Rigid Metal Conduit-Steel

UL 651	(2005; Rev thru May 2007) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(1993; Rev thru Apr 2006) Standard for Panelboards
UL 674	(2003; Rev thru Apr 2006) Standard for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 698	(2006) Industrial Control Equipment for Hazardous (Classified) Locations
UL 6A	(2000; Rev thru Jan 2004) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 719	(2006; Rev thru Jan 2007) Nonmetallic-Sheathed Cables
UL 797	(2004) Standard for Electrical Metallic Tubing -- Steel
UL 817	(2001; Rev thru May 2007) Cord Sets and Power-Supply Cords
UL 83	(2003; Rev thru Apr 2006) Standard for Thermoplastic-Insulated Wires and Cables
UL 845	(2005; Rev thru Aug 2006) Standard for Motor Control Centers
UL 854	(2004; Rev thru Oct 2007) Service-Entrance Cables
UL 857	(2001; Rev thru Nov 2002) Busways
UL 869A	(2006) Reference Standard for Service Equipment
UL 870	(1995; Rev thru Jul 2003) Standard for Wireways, Auxiliary Gutters, and Associated Fittings
UL 877	(1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 886	(1994; Rev thru Nov 2005) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 943	(2006) Ground-Fault Circuit-Interrupters
UL 984	(1996; Rev thru Sept 2005) Hermetic Refrigerant Motor-Compressors

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

SD-02 Shop Drawings

Panelboards[; G][; G, [_____]]

Transformers[; G][; G, [_____]]

Busway[; G][; G, [_____]]

Cable trays[; G][; G, [_____]]

Motor control centers[; G][; G, [____]]

Include 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. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Wireways[; G][; G, [____]]

[Load centers for housing units[; G][; G, [____]]]

Marking strips drawings[; G][; G, [____]]

SD-03 Product Data

Receptacles[; G][; G, [____]]

Circuit breakers[; G][; G, [____]]

Switches[; G][; G, [____]]

Transformers[; G][; G, [____]]

Enclosed circuit breakers[; G][; G, [____]]

Motor controllers[; G][; G, [____]]

[Combination motor controllers[; G][; G, [____]]]

[Load centers for housing units[; G][; G, [____]]]

Manual motor starters[; G][; G, [____]]

[Residential load centers[; G][; G, [____]]]

[Metering[; G][; G, [____]]]

[Meter base only[; G][; G, [____]]]

CATV outlets[; G][; G, [____]]

Telecommunications Grounding Busbar[; G][; G, [____]]

Surge protective devices[; G][; G, [____]]

Submittals shall include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test[; G][; G, [____]]

Grounding system test[; G][; G, [____]]

Transformer tests[; G][; G, [____]]

Ground-fault receptacle test[; G][; G, [____]]

SD-07 Certificates

Fuses[; G][; G, [____]]

SD-09 Manufacturer's Field Reports

Transformer factory tests

[SD-10 Operation and Maintenance Data

NOTE: Delete SD-10 and its subparagraph on
LANTNAVFACENGCOM projects unless "metering" or other
special equipment is added to the section which
requires O&M manuals.

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

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

Submit operation and maintenance data in accordance with Section
01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein.

]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" 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. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of 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. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be 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 shall not be used, unless specified otherwise.

1.5 MAINTENANCE

NOTE: Delete subparagraph on LANTNAVFACENGCOM
projects unless "metering" or other special
equipment is added to the section which requires O&M
manuals.

[1.5.1 Electrical Systems

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. This shall include:

- 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

The equipment items shall be supported by service organizations which 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, Section
13080 and Section 16070A) must be edited to suit the
project and be included 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.

Seismic details shall[conform to[Section 13 48 00, SEISMIC PROTECTION FOR
MISCELLANEOUS EQUIPMENT][and to[Section 26 05 48.00 10, SEISMIC
PROTECTION FOR ELECTRICAL EQUIPMENT]][be as indicated].

] PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

NOTE: Choose the last bracketed sentence for Army projects.

Materials, equipment, and devices shall, as a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70.

2.2 CONDUIT AND FITTINGS

NOTE: For Navy projects, do not use Electrical Nonmetallic Tubing (ENT) without specific written approval from the cognizant electrical design branch manager.
Malleable iron seal electrical fittings shall be used in fuel valve pits and similar locations where fittings are exposed to potential freeze thaw environments. Nonmetallic fittings have failed in these environments.

Shall conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

NEMA C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

NEMA C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

NOTE: Do not use fiberglass in buildings. With advanced approval, for acceptable reasons, it may be used for service entrance or below grade use.

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, NEMA C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(one millimeter (40 mils) 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 shall be 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: Use steel for SOUTHNAVFACENGCOM projects.

[Steel] [Die cast] compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NOTE: Do not use fiberglass in buildings. With advanced approval, for acceptable reasons, it may be used for service entrance or below grade use.

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 allowed by the Authority Having Jurisdiction.

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

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

2.3.2 Surface Nonmetallic Raceway

NOTE: Designer should 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. Receptacles shall be as specified herein and shall be spaced minimum of one every [455] [_____] mm [18] [_____] inches.][Alternate receptacles shall be wired on different circuits.]

2.4 BUSWAY

NOTE: Phase sequence of voltages, orientation,
etc., should be indicated on the drawings for
existing transformers, switchboards, switchgear,
motor control centers, etc.

NEMA BU 1.1, UL 857. Buses shall be[copper][or][aluminum]. Busways shall be rated [_____] volts, [_____] continuous current amperes, three-phase,[three-][four-]wire, and include integral or internal[50-percent] ground bus. Short circuit rating shall be[[_____] root mean square (rms) symmetrical amperes minimum][as indicated].[Busway systems shall be suitable for use indoors.] Enclosures shall be[steel][aluminum][metallic]. Hardware shall be plated or otherwise protected to resist corrosion. Joints shall be one-bolt type with through-bolts, which can be checked for tightness without deenergizing system. Maximum hot spot temperature rise at any point in busway at continuous rated load shall not exceed 55 degrees C above maximum ambient temperature of 40 degrees C in any position. Provide internal barriers to prevent movement of superheated gases. Contractor shall 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 shall be unventilated,][unventilated, totally enclosed] low-impedance busway. Bus bars shall be fully covered with insulating material, except at stabs. Entire busway system shall be polarized.

2.4.2 Plug-In Busways

Unventilated type. Plug-in units shall be[fusible, handle-operated, switch type, horsepower-rated][circuit breaker-type][handle-operated, switch type, equipped with high interrupting-capacity, current-limiting fuses]. Bus bars shall be covered with insulating material throughout, except at joints and other connection points. [A hook stick of suitable length shall be provided for operating plug-in units from the floor.].

2.5 CABLE TRAYS

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

NEMA VE 1. Cable trays shall form a wireway system, and shall be of nominal [75] [100] [150] mm ([3] [4] [6] inch) [3] [4] [6] inch depth [as indicated]. Cable trays shall be constructed of [aluminum] [copper-free aluminum] [steel that has been zinc-coated after fabrication]. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. [Radius of bends shall be [305] [610] [915] mm ([12] [24] [36] inches) [12] [24] [36] inches.] [Radius of bends shall be 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) [2,] [4,] [6,] [8,] [12,] [18,] [and] [24] inch width and [25,] [50,] [and] [100] mm ([1,] [2,] [and] [4] inch) [1,] [2,] [and] [4] inch depth with maximum wire mesh spacing of 50 by 100 mm (2 by 4 inch) 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% 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) [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) [6] [12] [18] [24] [30] [36] inch

width] with maximum rung spacing of [150] [225] [305] [455] mm
([6] [9] [12] [18]) [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) 6 inches in width.

Provide [size as indicated] [of nominal [75] [100] [150] mm ([3] [4] [6]
inch) [3] [4] [6] inch width]. Trays shall be one-piece construction
having slots spaced not more than 115 mm (4 1/2 inches) 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) [6] [12] [18] [24] [30] [36] inch width].
Solid covers [shall] [shall not] be provided.

[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: Do not use for Navy projects. Navy does not
allow the use of open-top cable supports
(J-supports) or closed ring cable supports (D-rings)
for telecommunications pathway.

2.6.1 Open Top Cable Supports

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

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Closed ring
cable supports shall be [[galvanized] [zinc-coated] steel] [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

Boxes shall be [adjustable] [nonadjustable] and concrete tight. Each outlet shall consist 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) [3/4] [1] [1 1/4] [2 1/8] inch threaded plug. Telecommunications outlets shall consist of [surface-mounted, horizontal] [flush], aluminum or stainless steel housing with a receptacle as specified and [25 mm (one inch) one inch] bushed side opening [19 mm (3/4 inch) 3/4 inch] top opening]. Receptacle outlets shall consist of [surface-mounted, horizontal] [flush] aluminum or stainless steel housing with duplex-type receptacle as specified herein. Provide gaskets where necessary to ensure watertight installation. [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 standard type [100 mm square by 54 mm deep (4 inches square by 2 1/8 inches deep)] [120 mm square by 54 mm deep (4 11/16 inches square by 2 1/8 inches)] [4 inches square by 2 1/8 inches deep] [4 11/16 inches square by 2 1/8 inches deep]. [Outlet boxes for wall-mounted telecommunications outlets shall be 100 by 54 by 54 mm (4 by 2 1/8 by 2 1/8 inches) 4 by 2 1/8 by 2 1/8 inches deep.] Depth of boxes shall be large enough to allow manufacturers' recommended conductor bend radii. [Outlet boxes for fiber optic telecommunication outlets shall include a minimum 10 mm (3/8 inch) 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum 27 mm (1 inch) 1 inch conduit system.] [Outlet boxes for handicapped telecommunications station shall be 100 by 54 by 54 mm (4 by 2 1/8 by 2 1/8 inches) 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 outlet box with plastic cover, where required, and single receptacle with clock outlet plate. Receptacle shall be recessed sufficiently within box to allow complete insertion of standard cap, flush with plate. Suitable clip or support for hanging clock shall be secured to top plate. Material and finish of plate shall be as specified in paragraph DEVICE PLATES of this section.

]2.8 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 1640 mL 100 cubic inches, UL 50, hot-dip, zinc-coated, if sheet steel.

2.9 WIRES AND CABLES

Wires and cables shall meet applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Wires and cables manufactured more than 12 months prior to date of delivery to site shall not be used.

2.9.1 Conductors

NOTE: 1. For Navy projects, unless directed otherwise, do not specify the use of aluminum conductors for interior distribution circuits of 600 VAC or less.

2. The use of aluminum conductors in mission critical facilities, dormitories, officers' housing, and transient living facilities is limited to service entrance conductors only, sizes No. 4 AWG and larger.

NOTE: In overseas locations, for conductors No. 10 AWG and smaller diameter, consideration may be given 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.

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. [All conductors shall be copper.] [Conductors indicated to be No. 6 AWG or smaller diameter shall be copper. Conductors indicated to be No. 4 AWG and larger diameter shall be 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 shall be limited. When necessary, specify the following: "Conductors shall be compact stranded utilizing method of stranding specified in ASTM B 400; however, conductor material shall be as specified herein."

Aluminum conductors shall be AA-8000 series electrical grade aluminum alloy conductors. Type EC/1350 aluminum is not acceptable. Should Contractor choose to provide aluminum for conductors No. 4 AWG and larger diameter, Contractor shall be 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

Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote-control and signal circuits, No. 14 AWG; for Class 2 low-energy, remote-control and signal circuits, No. 16 AWG; and for Class 3 low-energy, remote-control, alarm and signal circuits, No. 22 AWG.

2.9.2 Color Coding

Provide for service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be 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 shall be 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. Designer should use THWN values (75 degrees C) for ampacities of THWN/THHN.

Unless specified or indicated otherwise or required by NFPA 70, power and lighting wires shall be 600-volt, [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 shall be 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 B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, 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 J-STD-607-A. The TBB

shall be a minimum No. 6 AWG and be 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 J-STD-607-A. The bonding conductor for telecommunications shall be sized 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

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, designer shall consult with NAVFAC cognizant EFD/EFA electrical design branch manager and obtain written approval before specifying this wiring method.

UL 1569; NFPA 70, Type MC cable.

] [2.9.9 Armored Cable

NOTE: Type AC cable has more restricted applications than MC cable but offers the same advantages. Review NFPA 70. For Navy projects, consult with cognizant EFD/EFA electrical design branch manager and obtain written approval before specifying AC cable. Do not use for EFA CHES projects without written approval.

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.
Drawings shall clearly show the MI cable. 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. Sheathing containing asbestos fibers
shall not be used.

] [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 shall be 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 three sentences of paragraph for
brig facilities only.

Provide UL listed, one-piece device plates for outlets to suit the devices
installed. For metal outlet boxes, plates on unfinished walls shall be of
zinc-coated sheet steel or cast metal having round or beveled edges. For
nonmetallic boxes and fittings, other suitable plates may be provided. [

Plates on finished walls shall be nylon or lexan, minimum 0.792 mm 0.03 inch wall thickness. Plates shall be same color as receptacle or toggle switch with which they are mounted.][Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.792 mm 0.03 inch thick.] Screws shall be machine-type with countersunk heads in color to match finish of plate. Sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations."[Device plates in areas normally accessible to prisoners shall be 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. Handles shall be [white][ivory][brown] thermoplastic. Wiring terminals shall be screw-type, side-wired [or of the solderless pressure type having suitable conductor-release arrangement]. Contacts shall be silver-cadmium and contact arm shall be one-piece copper alloy. Switches shall be 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 pilot lights that are integrally constructed as a part of the switch's handle. The pilot light shall be red and shall illuminate whenever the switch is closed or "on". The pilot lighted switch shall be rated 20 amps and 120 volts or 277 volts as indicated. Provide 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: Switches requiring frequent operation should be the heavy duty-type and should be so indicated on the drawings.

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Fused switches shall utilize Class R fuseholders and fuses, unless indicated otherwise. Switches serving as motor-disconnect means shall be horsepower rated. Provide switches in NEMA [1][3R] [____], enclosure [as indicated] per NEMA ICS 6.

2.13 FUSES

NOTE: Designer shall 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]. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers[or other circuit protective devices] shall be coordinated for proper operation. Submit coordination data for approval. Fuses shall have voltage rating not less than circuit voltage.

2.13.1 Fuseholders

Provide in accordance with UL 512.

2.13.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class[RK-1][RK-5][time-delay type]. Associated fuseholders shall be Class R only.

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. Designer will select the proper grade for the application. Hard use receptacles are suitable for normal use and heavy use. Use hospital grade receptacles only for those applications that exceed capabilities of hard use.

2. Do not use solderless pressure type receptacles on Navy projects.

3. 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.

[UL 498, hard use, heavy-duty,][UL 498, hospital grade,] grounding-type. Ratings and configurations shall be as indicated. Bodies shall be of[white][ivory][brown] as per NEMA WD 1. Face and body shall be thermoplastic supported on a metal mounting strap. Dimensional requirements shall be per NEMA WD 6. Provide screw-type, side-wired wiring terminals[or of the solderless pressure type having suitable conductor-release arrangement]. Connect grounding pole to mounting strap. The receptacle shall contain triple-wipe power contacts and double or triple-wipe ground contacts.

2.14.1 Switched Duplex Receptacles

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

2.14.2 Weatherproof Receptacles

Provide in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. Provide caps with a spring-hinged flap. Receptacle shall be UL listed for use in "wet locations with plug in use."

2.14.3 Ground-Fault Circuit Interrupter Receptacles

NOTE: For LANTNAVFACENGCOM projects, use GFI

terminology in lieu of GFCI. For child care center projects, coordinate project drawings and specifications to include GFCI/GFI for receptacles in bathrooms, kitchens, laundry facilities, exterior locations, and swimming pools. NAVFACENGCOM has established these GFCI/GFI safety standards for child care centers at a higher level of protection than NFPA 70's minimum requirements as a result of a GAO report and DOD concern about health and safety at these facilities.

UL 943, duplex type for mounting in standard outlet box. Device shall be capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A[GFCI][GFI] 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. Plugs shall be UL listed 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: The 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.

2.15 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 LANTNAVFACENGCOM projects, use the first bracketed paragraph.

[UL 67 and UL 50 having a short-circuit current rating[as indicated][of 10,000 amperes symmetrical minimum]. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped[unless indicated otherwise]. Design shall be 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. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted["above"] [or] ["below"] branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).[Provide new directories for existing panels modified by this project as indicated.] Type directories and mount in holder behind transparent protective covering.[Panelboards shall be listed and labeled for their intended use.] Panelboard shall have nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.]

[UL 67 and UL 50. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped. Design shall be 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. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated. Directories shall indicate load served by each circuit of panelboard. Directories shall also indicate source of service (upstream panel, switchboard, motor control center, etc.) to panelboard. Type directories and mount in holder behind transparent protective covering. Panelboard shall have nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.]

2.15.1 Enclosure

Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from sheet steel of not less than 3.5 millimeters (No. 10 gauge No. 10 gauge if flush-mounted or mounted outdoors, and not less than 2.7 millimeters (No. 12 gauge) No. 12 gauge if surface-mounted indoors, with full seam-welded box ends. Cabinets mounted outdoors or flush-mounted shall be hot-dipped galvanized after fabrication. Cabinets shall be painted in accordance with paragraph PAINTING. Outdoor cabinets shall be of NEMA 3R raintight with[conduit hubs welded to the cabinet][a removable steel plate 7 millimeters (1/4 inch) 1/4 inch thick in the bottom for field drilling for conduit connections]. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 3 millimeters (1/8 inch) 1/8 inch. Holes shall be provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a

15 millimeter (1/2 inch) 1/2 inch clear space between the back of the cabinet and the wall surface. Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that doors over 600 millimeters (24 inches) 24 inches long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.15.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed 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.]

[2.15.2.1 Panelboard Neutrals for Non-Linear Loads

UL listed, and panelboard type shall have been specifically UL heat rise tested for use on non-linear loads. Panelboard shall be 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. Verification of the testing procedure shall be provided upon request. Two neutral assemblies paralleled together with cable is not acceptable. Nameplates for panelboard rated for use on non-linear loads shall be marked "SUITABLE FOR NON-LINEAR LOADS"and shall be in accordance with paragraph FIELD FABRICATED NAMEPLATES. 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 most applications, plug-in circuit breakers are not permitted, and the last sentence is required.

For residential applications, paragraph RESIDENTIAL LOAD CENTERS or LOAD CENTERS FOR HOUSING UNITS should be used instead of PANELBOARDS unless panelboards with bolt-on breakers are required by the local Activity.

NOTE: For LANTNAVFACENGCOM projects, use the second bracketed last sentence of the paragraph.

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 shall be mounted. Breaker terminals shall be 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 without a self-contained bracket and not secured by a positive locking

device requiring mechanical release for removal are unacceptable.][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. Breaker design shall be 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[GFCI][GFI]

NOTE: For LANTNAVFACENGCOM projects, use GFI terminology in lieu of GFCI. For child care center projects, coordinate project drawings and specifications to include GFCI/GFI for receptacles in bathrooms, kitchens, laundry facilities, exterior locations, and swimming pools. NAVFACENGCOM has established these GFCI/GFI safety standards for child care centers at a higher level of protection than NFPA 70's minimum requirements as a result of a GAO report and DOD concern about health and safety at these facilities. NFPA requires GFCI/GFI equipment protection at a higher mA level on certain exterior circuits.

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of[6 milliamperes or greater per requirements of UL 943 for Class A[GFCI][GFI] devices, for personnel protection,][and][20 milliamperes or greater per requirements of UL 943 for Class B[GFCI][GFI] per equipment protection.]

2.15.3.3 Circuit Breakers for HVAC Equipment

Circuit breakers for HVAC equipment having motors (group or individual) shall be marked for use with HACR type and UL listed as HACR type.

2.15.3.4 Arc-Fault Circuit-Interrupters

NOTE: NFPA 70 requires that all branch circuits that supply 125 volt, single phase, 15 and 20 ampere outlets (receptacles, luminaires, smoke detectors etc) installed in dwelling unit bedrooms shall be protected by an arc-fault circuit-interrupter to provide protection to the 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 or EFD/EFA.

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as indicated.[Two pole arc-fault circuit-interrupters shall be 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. Switches serving as motor disconnect means shall be kilowatt (horsepower) horsepower rated.

] [2.15.5 400 Hz Panelboard and Breakers

Panelboards and breakers for use on 400 Hz systems shall be "400 Hz" rated and labeled.

] [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), conforming to UL 67 and UL 50. RLCs for use as service disconnecting means shall additionally conform to UL 869A. RLCs shall be circuit breaker equipped. Design shall be 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. Where "space only" is indicated, make provisions for future installation of breakers sized as indicated.[Load centers shall have keyed locks.] Printed directories shall be provided.

2.16.1 RLC Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed 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 shall be UL listed as suitable for the type of conductor provided.

2.16.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be 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[GFCI][GFI]

NOTE: Include GFCI for receptacles in bathrooms, kitchens, garages, unfinished basements, and exterior locations in accordance with NFPA 70. Use GFI terminology for LANTNAVFACENGCOM.

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A[GFCI][GFI] devices.

]2.16.2.3 Arc-Fault Circuit-Interrupters

NOTE: NFPA 70 requires that all branch circuits that supply 125 volt, single phase, 15 and 20 ampere outlets (receptacles, luminaires, smoke detectors etc) installed in dwelling unit bedrooms (family housing) shall be protected by an arc-fault circuit-interrupter to provide protection to the 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 or EFD/EFA.

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as

indicated.[Two pole arc-fault circuit-interrupters shall be 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: Use the following only for single phase,
residential panelboards on LANTNAVFACENGCOM projects.

Single-phase panelboards for housing units on this project shall be load center type, circuit breaker equipped, conforming to UL 67 and UL 50. Panelboards shall have a series short-circuit current rating of 22,000 amperes symmetrical minimum for the main breaker and the branch breakers. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Design shall be 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. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Where "space only" is indicated, make provisions for future installation of breakers. Provide cover with latching door. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from panel MDP). Type directories and mount behind transparent protective covering on inside of panel door in a manner approved by the Contracting Officer.

2.17.1 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Bus bars shall be copper or aluminum, and shall be 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 shall be UL listed as suitable for type of conductor provided. Half-size and tandem breakers are not acceptable. 15 and 20 ampere breakers shall be switch duty rated. Breakers shall 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. Breaker design shall be 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 125 volt, single phase, 15 and 20 ampere outlets (receptacles, luminaires, smoke detectors etc) installed in dwelling unit bedrooms (family housing) shall be protected by an arc-fault circuit-interrupter to provide protection to the 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 or EFD/EFA.

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as indicated.[Two pole arc-fault circuit-interrupters shall be 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); shall conform to UL 508 and UL 489 and shall be provided as shown. MSCPs shall 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. MSCPs shall be rated 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 PAD-MOUNTED TRANSFORMERS, Section 26 12 19.20 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS, or Section 26 11 13 SECONDARY UNIT SUBSTATION FOR ALL PROJECTS; or Section 26 11 16.00 20 PRIMARY UNIT SUBSTATION for Navy projects; or Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION for Army projects. Specify 80 C or 115 C transformers when transformer is loaded above 60 percent of nameplate and has continuous duty cycle. 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.

NEMA ST 20, general purpose, dry-type, self-cooled, [ventilated] [unventilated] [sealed]. Provide transformers in NEMA [1] [3R] [_____] enclosure. Transformer shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding [150] [115] [80] degrees C under full-rated load in maximum ambient of 40 degrees C. [Transformer of 150 degrees C temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating.] [Transformer of 115 degrees C temperature rise shall be capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.] [Transformer of 80 degrees C temperature rise shall be capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.] [Transformers shall be 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, and not available in K-rated or quiet types.

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, shall be energy efficient type. Minimum efficiency, based on factory test results, shall not be less than NEMA Class 1 efficiency as defined by **NEMA TP 1**.

[2.20.2 Transformers With Non-Linear Loads

NOTE: Analysis of the connected loads shall be made

to determine the harmonic contents and the appropriate K-Factor rating. K-Factor is defined as the sum from $h=1$ to infinity of $I_h(\text{pu})^2 h^2$ where $I_h(\text{pu})$ is the rms current at harmonic "h" (per unit of rated rms load current) and h is the harmonic order. 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). Caution should be used 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.

Transformer insulation shall be a UL recognized 220 degrees C system. Neither the primary nor the secondary temperature shall exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load. 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](#). Transformers evaluated by the UL K-Factor evaluation shall be listed for [115] [80] degrees C average temperature rise only. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise shall not be acceptable. K-Factor rated transformers shall have an impedance range of 3 percent to 5 percent, and shall have 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 shall be thoroughly coordinated with and cross-referenced in all affected mechanical sections. UFC 3-410-01FA, HEATING, VENTILATING, AND AIR CONDITIONING, provides application data on motors and controllers.

[NEMA MG 1](#) [except fire pump motors shall be as specified in [Section 21 30 00](#)] FIRE PUMPS; hermetic-type sealed motor compressors shall also comply with [UL 984](#). 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. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters. Motors for operation on 208-volt, 3-phase circuits shall have terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits shall have terminal voltage rating of 460 volts. Motors shall be designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating. Unless otherwise indicated, motors rated [745 Watts \(1 HP\)](#) [1 HP](#) and above shall be continuous duty type.

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

2.21.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11. 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.

2.21.2 Premium Efficiency Polyphase Motors

Polyphase motors shall be selected based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. In addition, continuous rated, polyphase squirrel-cage medium induction motors shall 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[, 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 shall conform to the requirements specified herein. Control wiring shall be provided under, and conform to the requirements of the section specifying the associated equipment.

2.22 MOTOR CONTROLLERS

NOTE: Motor and motor controller specifications shall be thoroughly coordinated with and cross-referenced in all affected mechanical sections. UFC 3-410-01FA, HEATING, VENTILATING, AND AIR CONDITIONING provides application data on motors and controllers. Indicate NEMA size of controller on mechanical drawings.

UL 508, NEMA ICS 1, and NEMA ICS 2,[except fire pump controllers shall be as specified in Section 21 30 00 FIRE PUMPS]. Controllers shall have thermal overload protection in each phase and shall have one spare normally open and one spare normally closed auxiliary contact. 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. Magnetic-type motor controllers shall have undervoltage protection when used with momentary-contact pushbutton stations or switches and shall have undervoltage release when used with maintained-contact pushbutton stations or switches. When used with pressure, float, or similar automatic-type or maintained-contact switch, controller shall have hand/off/automatic selector switch. Connections to selector switch shall be such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in motor control circuit in "hand" and "automatic" positions. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device shall be made in accordance with indicated or manufacturer's approved wiring diagram.[Selector switch shall have means for locking in any position.] For each motor not in sight of controller or where controller disconnecting means is not in sight of motor location and driven machinery location, controller disconnecting means shall be capable of being locked in open position. As an alternative, provide a manually operated, lockable, nonfused switch which disconnects motor from supply source within sight of motor. Overload protective devices shall provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case. Cover of combination motor controller and manual switch or circuit breaker shall be 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.[Minimum short circuit withstand rating of combination motor controller shall be [_____] rms symmetrical amperes.][Provide controllers in hazardous locations with classifications as indicated].

2.22.1 Control Wiring

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to 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

NEMA ICS 4. Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and

space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. The Contractor shall submit data showing that the 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 shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet 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 shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. The terminals shall be 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, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have 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 shall have maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers shall conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits, shall have 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]. One secondary lead shall be fused; other shall be 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 shall have maximum voltage of 120 volts derived from a separate control source. Provide terminals and terminal boards. Provide separate control disconnect switch within controller. One secondary lead shall be fused; other shall be 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 shall have compelling relays and shall be
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 shall be 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 shall determine, based on the
power system characteristics and motor usage, where
reduced-voltage controllers shall be specified.
Refer to UFC 3-520-01, INTERIOR ELECTRICAL SYSTEMS,
for detailed discussion of these reduced voltage
starter types and for guidance in their selection
and application.

Provide for polyphase motors [_____] kilowatt horsepower and larger.
Reduced-voltage starters shall be single-step, closed transition[
autotransformer,] [reactor,] [primary resistor-type,] [solid state-type,]
or as indicated, and shall have 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 shall be [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 shall be green; jewels for other purposes shall be [white] [red] [amber].]

2.24 **MOTOR CONTROL CENTERS**

NOTE: Motor control center should be specified 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.

NOTE: 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

UL 845, NEMA ICS 2, NEMA ICS 3. Wiring shall be Class [I] [II], Type [A] [B] [C], in NEMA Type [1] [3R] [12] [_____] enclosure. Provide control centers suitable for operation on [_____] -volt, [_____] -phase, [_____] -wire, [_____] Hz system and shall have minimum short-circuit withstand and interrupting rating of [100,000] [65,000] [42,000] [25,000] [_____] amperes rms symmetrical. Incoming power feeder shall be [bus duct] [cable] entering at the [top] [bottom] of enclosure and terminating on [terminal lugs] [main protective device]. [Main protective device shall be [molded case circuit breaker] [low-voltage power circuit breaker] [fusible switch] rated at [_____] amperes rms symmetrical interrupting capacity.] [Arrange busing so that control center can be expanded from both ends.] Interconnecting wires shall be copper. Terminal blocks shall be 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 shall be braced to withstand fault current of [100,000] [65,000] [42,000] [25,000] [_____] amperes rms symmetrical. Wiring troughs shall be isolated from horizontal and vertical bus bars.

2.24.1.1 Horizontal and Main Buses

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

NOTE: UFC 3-520-01, INTERIOR ELECTRICAL SYSTEMS, recommends the use of copper bus.

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

2.24.1.2 Vertical Bus

NOTE: UFC 3-520-01, INTERIOR ELECTRICAL SYSTEMS, recommends the use of copper bus.

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

2.24.1.3 Ground Bus

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

[2.24.1.4 Neutral Bus

Insulated neutral bus shall be provided continuous through the motor control center; neutral shall be full rated. Lugs of appropriate capacity shall be provided, as required.

]2.24.2 Motor Disconnecting Devices and Controllers

Shall comply with paragraph COMBINATION MOTOR CONTROLLERS.

[2.24.3 Combination Motor Controllers

NOTE: Per LANTNAVFACENGCOM criteria, combination motor controllers are not normally used on

LANTNAVFACENGCOM projects, except when MCC's are used.

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

] 2.24.4 Space Heaters

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

Space heaters shall be provided where indicated on the drawings and shall be controlled using an adjustable 10 to 35 degrees C (50 to 90 degree F) thermostat, magnetic contactor, and a molded-case circuit breaker[and a 480-120 volt single-phase transformer]. The space heaters shall be 250-watt, 240 volt strip elements operated at 120 volts and shall be[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]. The contactors shall be open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

] 2.25 LOCKOUT REQUIREMENTS

Provide disconnecting means 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. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 23, "Mechanical."

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. 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/EIA-569-A 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 shall provide riser diagram of
system on drawings and provide empty conduit to
exterior location for CATV service entrance.

3. Choose Section 27 54 00.00 20, COMMUNITY
ANTENNA TELEVISION (CATV) SYSTEMS for Navy projects
and Section 16815A CABLE TELEVISION PREMISES
DISTRIBUTION SYSTEM for Army projects where complete
CATV system is provided. Delete paragraphs CATV
OUTLETS and CATV FACEPLATES when section 27 54 00.00
20 or section 16815A are used on the project.

[Additional CATV requirements are specified in[Section 27 54 00.00 20,
COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS.][Section 27 05 14.00 10,
CABLE TELEVISION PREMISES 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 shall
include designation labels and label covers for circuit identification.]
Faceplate color shall 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 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) 3/4
inch thick, [1200 by 2400 mm (4 by 8 feet)][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: For LANTNAVFACENGCOM projects, delete
"sectional type" and " 6100 mm (20 foot) 20 foot
length," except for projects at Portsmouth Naval
Hospital, Portsmouth, VA.

2.28.1 Ground Rods

UL 467. Ground rods shall be[sectional type,] copper-clad steel, with minimum diameter of 19 mm (3/4 inch) 3/4 inch and minimum length[of 3050 mm (10 feet)][of 6100 mm (20 feet)][of 10 feet][of 20 feet].

[2.28.2 Ground Bus

A copper ground bus shall be 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 J-STD-607-A. Busbars shall be electrotin-plated for reduced contact resistance. If not plated, the busbar shall be cleaned prior to fastening the conductors to the busbar, and an anti-oxidant shall be applied 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)] shall be 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 inch) 0.25 in thick x 100 mm (4 in) 4 in wide for the TMGB[and 50 mm (2 in)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, shall be 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 shall be as indicated. Equipment in hazardous locations shall comply with UL 877 for circuit breakers, UL 886 for outlet boxes and fittings, UL 1010 for receptacles, UL 674 for motors, and UL 698 for industrial controls.

]2.30 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have 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.

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) 0.125 inch thick, white with [black] [] center core.[Provide red laminated plastic label with white center core where indicated.] Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches) one by 2.5 inches. Lettering shall be a minimum of 6.35 mm (0.25 inch) 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. The marking shall be 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 shall be steel[epoxy painted][galvanized] 16 gauge for heights and depths up to 150 by 150 mm (6 by 6 inches) 6 by 6 inches, and 14 gauge for heights and depths up to 305 by 305 mm (12 by 12 inches) 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 19.20, SINGLE-PHASE PAD-MOUNTED TRANSFORMER and Section 33 71 01, OVERHEAD TRANSMISSION AND DISTRIBUTION. For LANTNAVFACENGCOM projects only: If meter base is mounted more than 5 feet from the building, this specification section number and title should be changed to LANTDIV regional Section 16403, WIRING SYSTEMS. Appropriate verbiage should be added 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.

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

NOTE: Form 2S, in text below, is for single-phase, three-wire systems, for other system configurations, designer shall 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: +/- 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: Shall be 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; 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.

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.

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 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](#). Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-

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)]

Surge protective devices at the service entrance shall have a minimum surge current rating of 80,000 amperes per mode minimum[and downstream protectors shall be rated 40,000 amperes per mode minimum]. The maximum line to neutral (L-N) Suppressed Voltage Rating (SVR) shall be:

[500V for 120V, single phase system]

[500V for 120/240V, single phase system]

[500V for 208Y/120V, three phase system]

[900V for 480Y/277V, three phase system]

The minimum MCOV (Maximum Continuous Operating Voltage) rating shall be:

[150V for 120V, single phase system]

[300/150V for 120/240V, single phase system]

[300/150V for 208Y/120V, three phase system]

[600/320V for 480Y/277V, three phase system]

EMI/RFI filtering shall be provided for each mode with the capability to attenuate high frequency noise. Minimum attenuation shall be 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.

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of [NEMA 250](#) corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment

prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray, [and equipment located outdoors shall be ANSI[Light Gray][Dark Gray]]. 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 shall include routine NEMA ST 20 transformer test results on each transformer and also contain 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).

Analyses shall be prepared as specified in Section 16475A, 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, shall 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 shall be 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 shall 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

Work in hazardous locations, as defined by NFPA 70, shall be performed 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. Conduit shall have tapered threads.

] 3.1.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures shall be 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, each enclosure, new and existing, shall be labeled as one of several enclosures containing service entrance disconnect devices. Label, at minimum, shall indicate number of service disconnect devices housed by enclosure and shall 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, shall be 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 shall be 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 shall be 16 mm (1/2 inch) 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 150 mm (6 inches) 6 inches. Conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors shall be firestopped in accordance with Section 07 84 00, FIRESTOPPING.

3.1.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire shall be plastic having minimum 890-N (200-pound) 200-pound force tensile strength. Leave minimum 915 mm (36 inches) 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.

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.

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.

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, conduits shall be rigid metallic type and outlet boxes shall be cast metal-type with threaded hubs. Install conduits flat against wall; offsets or

"kicks" shall be permitted only to enter outlet box. Support conduits on 1525 mm (5 foot) 5 foot maximum centers and within 305 mm (12 inches) 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) 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 severe 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 and PVC Schedule 80
 - (1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.
 - (2) Do not use in hazardous (classified) areas.
 - (3) Do not use in fire pump rooms.
 - (4) Do not use in penetrating fire-rated walls or partitions, or

fire-rated floors.

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

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

NOTE: Do not use ENT for NAVFACENGCOM projects without written approval from the NAVFAC EFD/EFA electrical design engineering branch manager. NAVFAC EFD/EFA electrical design branch managers should consider the following information in evaluating ENT for specific projects. ENT may be provided in walls, floors, and ceilings only when protected by thermal barriers identified as having minimum 15-minute finish rating. If ENT is used, the Contractor shall provide any required thermal barriers, whether indicated or not. Include the following restrictions for ENT where ENT is allowed by the Authority Having Jurisdiction in overseas locations.

[b. Electrical Nonmetallic Tubing

(1) Do not install underground.

(2) Do not encase in concrete except when provided with fittings identified for this purpose are used for connections.

(3) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(4) Do not use in hazardous areas.

(5) Do not use outdoors.

(6) Do not use in sizes larger than 53 mm (2 inch) 2 inch.

(7) Do not run exposed in buildings exceeding three floors above grade, where "first floor" is as defined in NFPA 70.]

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

]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 Service Entrance Conduit, Overhead

Rigid steel or IMC from service entrance to service entrance fitting or weatherhead outside building.

3.1.6.6 Service Entrance Conduit, Underground

NOTE: For CHESNAVFACENGCOM and PACNAVFACENGCOM projects, DO NOT USE PVC Type-EPC 40 conduit.

PVC, Type-EPC 40, galvanized rigid steel or steel IMC. Underground portion shall be encased in minimum of 75 mm 3 inches of concrete and shall be installed minimum 460 mm 18 inches below slab or grade.

3.1.6.7 Underground Conduit Other Than Service Entrance

NOTE: Soil conditions in some locations require that underground conduit be supported to prevent damage due to settlement. The designer shall determine if the problem exists, and, if so, determine 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 shall extend minimum 150 mm 6 inches above floor.

[3.1.6.8 Conduit Interior to Buildings for 400 Hz Circuits

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

]3.1.6.9 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.6.10 Conduit Installed Under Floor Slabs

NOTE: Designer shall 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. Consideration shall be given 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 shall be located a minimum of [305] [_____] mm ([12] [_____] inches) [12] [_____] inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.6.11 Conduit Through Floor Slabs

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

[3.1.6.12 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 shall 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 LANTNAVFACENGCOM projects, use second bracketed option for conduit type.

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

]3.1.6.13 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) 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.6.14 Conduit Support

Support conduit by pipe straps, wall brackets, 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. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant. 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 shall not cut

main reinforcing bars. 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 shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Installation shall be coordinated 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) 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.

3.1.6.15 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.

3.1.6.16 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. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.6.17 Flexible Connections

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

Provide flexible steel conduit between 915 and 1830 mm (3 and 6 feet) 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 shall be 16 mm (1/2 inch) 1/2 inch diameter. Provide liquidtight flexible[nonmetallic] conduit in wet and damp locations[and in fire pump rooms] for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.6.18 Telecommunications and Signal System Pathway

NOTE: For guidelines on conduit sizing, see UFC-3-580-02, TELECOMMUNICATIONS BUILDING CABLING

SYSTEM PLANNING, DESIGN, AND ESTIMATING and NFPA 70.

Install telecommunications pathway in accordance with TIA/EIA-569-A.

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

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

3.1.6.19 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/EIA-569-A. [Distribution system shall be 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][Distribution system shall be star topology with empty conduit and pullwire from each outlet to the headend equipment location].

3.1.7 Busway Installation

Installation shall 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. Hinges provided on risers shall be fixed type; 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 calk. 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 LANTNAVFACENGCOM 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/EIA-569-A, and TIA J-STD-607-A]. 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]. [Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly.] Adjacent cable tray sections shall be 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. Conductors run through smoke and fire partitions shall be installed in 103 mm (4 inch) 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. Penetrations shall be firestopped 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/EIA-569-A, and TIA J-STD-607-A][Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly.] Edges, fittings, and hardware shall be 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. Conductors that run through smoke and fire partitions shall be installed in 103 mm (4 inch) 4 inch rigid steel conduits with grounding bushing, extending 305 mm (12 inches) 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: Delete for Navy projects. Concern and some evidence exists that certain cable supports can have a detrimental effect on transmission performance of higher performance cabling systems. Devices that have small surface areas to support the cable laying horizontally in them are the types of supports in question. When a choice exists, it would be prudent to select a cable support with a wider surface area to support the cable as a precaution against potential problems. Another precaution would be to reduce the distance between the cable supports.

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. These types of supports shall be used to support a maximum of 50 6.4 mm (0.25 in) 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 shall be 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 shall be 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 shall be sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic [sheathed cable] conduit system. Each box shall have volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures shall be minimum 100 mm (4 inches) 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 shall be 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; fixtures shall be readily removable 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 lockwashers 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 shall be minimum 40 mm (1 1/2 inches) 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 100 mm (4 inches) 4 inches square, except that 100 by 50 mm (4 by 2 inch) 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets shall be a minimum of [100 mm square by 54 mm deep (4 inches square by 2 1/8 inches deep)] [120 mm square by 54 mm deep (4 11/16 inches square by 2 1/8 inches)] [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 shall be 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. Drawings shall clearly show the MI cable. Surge suppressors should be considered 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 shall be not less than those indicated for the conduit installation. Cables shall be fastened 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. Single-conductor cables of a circuit, having capacities of more than 50 amperes, shall terminate in a single box or cabinet opening. Individual conductors in all outlets and cabinets shall be color-coded.

]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 and Section 23 09 54.00 20, DIRECT DIGITAL CONTROL SYSTEMS for Navy projects or Section 23 09 23, DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS on Army projects. Choose the last bracketed sentence when a telecommunications system is provided in Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, color coding shall be by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, color coding shall be 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 23, DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS][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

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. 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, additional wire and cable designations for identification of remote (external) circuits shall be provided for the Government's wire designations. 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) 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.

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.][Interconnect all grounding media in or on the structure to provide a common ground potential. This shall include lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Interconnection to the gas line shall be made 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 J-STD-607-A**. 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: For LANTNAVFACENGCOM Projects: Use sectional type ground rods only on projects at Naval Hospital, Portsmouth, VA. Do not use chemically charged ground rods for Navy projects.

Provide cone pointed ground rods. The resistance to ground shall be measured using the fall-of-potential method described in **IEEE Std 81**. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, [_____] additional rods not less than **1830 mm (6 feet) 6 feet** on centers, [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 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 compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.19.3 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of [transformer neutrals and other electrical] [electrical] equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded 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) 4 inches above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. [For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, ground buses shall be provided and connected to the building grounding system. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.]

3.1.19.4 Resistance

 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.

Maximum resistance-to-ground of grounding system shall 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

 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.

Provide telecommunications grounding in accordance with the following:

- a. Telecommunications Grounding Busbars: Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. The TMGB shall be 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. The TGB shall be as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, the TGB shall be located near the backbone cabling and associated terminations. In addition, the TGB shall be placed 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, that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure shall be bonded to the TGB.] Telecommunications grounding busbars shall be installed to maintain clearances as required by NFPA 70 and shall be insulated from its support. A minimum of 50 mm (2 inches) 2 inches separation from the wall is recommended to allow access to the rear of the busbar and the mounting height shall be adjusted 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 1 m (3 feet) 3 feet in length, the conductors shall be bonded 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. The TBB conductors shall be installed and protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. The bonding conductor between a TBB and a TGB shall be continuous. Where splices are necessary, the number of splices should be a minimum and they shall be accessible and located in telecommunications spaces. Joined segments of a TBB shall be connected using exothermic welding, irreversible compression-type connectors, or equivalent. All joints shall be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, the TBBs shall be

bonded together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. The TBB and GE shall not be connected to the pathway ground, except at the TMGB or the TGB.]

- c. Telecommunications Grounding Connections: Telecommunications grounding connections to the TMGB[or TGB] shall utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. All metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the TMGB[or TGB] shall be bonded to the TMGB[or TGB respectively]. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; each TMGB[and TGB] shall be bonded 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, the metal frame shall be bonded 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 shall 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 but shall be provided under the section specifying the associated equipment.

3.1.21 Elevator

NOTE: To achieve a complete specification, the electrical designer shall 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, this paragraph shall be modified accordingly. The drawings shall indicate required equipment connections. Elevator paragraph shall be coordinated with Section 14 21 00.00 20, ELECTRIC TRACTION ELEVATORS for Navy projects, Section 14 20 00, ELEVATORS, ELECTRIC and Section 14 24 00, HYDRAULIC ELEVATORS for all projects.

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[shall rough-in for Government-furnished equipment][shall 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

Repair of existing work[, demolition, and modification of existing electrical distribution systems] shall be performed 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

Existing concealed wiring to be removed shall be disconnected 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 shall include 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. Existing circuits of equipment shall remain energized. Circuits which are to remain but were disturbed during demolition shall have circuits wiring and power restored back to original condition.

] [3.1.24 Watthour Meters

NEMA 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.

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

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.

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. [Painting shall be 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

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

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

Each device subject to manual operation shall be operated 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 approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 250,000 ohms.

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

NOTE: If Ground-Fault Receptacle "line" and "load"

leads are reversed, "test" will trip downstream
loads but not trip the receptacle.

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

3.5.5 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.

[3.5.6 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.

] -- End of Section --