JOINT BASE LEWIS-McCHORD DESIGN STANDARDS DIVISION 26 – ELECTRICAL

SECTION 26 20 00 INTERIOR DISTRIBUTION SYSTEM

04/2023

PART 1 GENERAL

1.1 REFERENCES

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 C12.1 (2014; Errata 2016) Electric Meters – Code for

Electricity Metering ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1 (2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7 (2014) Requirements for Watthour Meter Sockets

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3 (2020) American National Standard for Electrical Metallic Tubing (EMT)

ANSI C80.5 (2020) American National Standard for Electrical Rigid Aluminum Conduit

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA BU 1.1 (2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less

NEMA FU 1 (2012) Low Voltage Cartridge Fuses

NEMA ICS 1 (2000; R 2015) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 3 (2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC

NEMA ICS 4 (2015) Application Guideline for Terminal Blocks NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures

NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures

NEMA KS 1 (2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)

NEMA MG 1 (2018) Motors and Generators

NEMA MG 10 (2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors

NEMA MG 11 (1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NEMA RN 1 (2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA ST 20 (2014) Dry-Type Transformers for General Applications

NEMA TC 2 (2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 3 (2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing

NEMA TC 14 (2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and
Fittings

NEMA VE 1 (2017) Metal Cable Tray Systems

NEMA WD 1 (1999; R 2020) Standard for General Color Requirements for Wiring Devices

NEMA WD 6 (2016) Wiring Devices Dimensions Specifications

NEMA Z535.4 (2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NFPA 70E (2021) Standard for Electrical Safety in the Workplace

NFPA 780 (2020) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1 (2020e) Commercial Building Telecommunications Infrastructure Standard

TIA-569 (2019e) Telecommunications Pathways and Spaces

TIA-607 (2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

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

10 CFR 431 Energy Efficiency Program for Certain Commercial and Industrial Equipment

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

29 CFR 1910.303 Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1 (2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit

UL 4 (2004; Reprint Mar 2021) UL Standard for Safety Armored Cable

UL 5 (2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings

UL 5A (2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings

UL 6 (2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel

UL 6A (2008; Reprint Mar 2021) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel

UL 20 (2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches

UL 44 (2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables

UL 50 (2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations UL 20 (2010; Reprint Feb 2012) General-Use Snap Switches

UL 67 (2018; Reprint Jul 2020) UL Standard for Safety Panelboards

UL 83 (2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables

UL 248-4 (2010; Reprint Apr 2019) Low-Voltage Fuses - Part 4: Class CC Fuses

UL 248-8 (2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class

J Fuses

UL 248-10 (2011; Reprint Aug 2020) Low-Voltage Fuses - Part 10: Class L Fuses

UL 248-12 (2011; Reprint Aug 2020) Low Voltage Fuses - Part 12: Class R Fuses

UL 248-15 (2018) Low-Voltage Fuses - Part 15: Class T Fuses

UL 360 (2013; Reprint Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit

UL 467 (2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

UL 486A-486B (2018; Reprint May 2021) UL Standard for Safety Wire Connectors

UL 486C (2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 498 (2017; Reprint Sep 2021) UL Standard for Safety Attachment Plugs and Receptacles

UL 506 (2017) UL Standard for Safety Specialty Transformers

UL 508 (2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment

UL 510 (2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

UL 514A (2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes

UL 514B (2012; Reprint May 2020) Conduit, Tubing and Cable Fittings

UL 514C (2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

UL 651 (2011; Reprint Mar 2020) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

UL 674 (2011; Reprint Dec 2020) UL Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations

UL 719 (2015; Reprint Jul 2021) UL Standard for Safety Nonmetallic-Sheathed Cables

UL 797 (2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel

UL 817 (2015; Reprint Sep 2021) UL Standard for Safety Cord Sets and Power-Supply Cords

UL 845 (2021) UL Standard for Safety Motor Control Centers UL 854 (2020) Standard for Service-Entrance Cables

UL 857 (2009; Reprint Apr 2021) UL Standard for Safety Busways UL 869A (2006; Reprint Jun 2020) Reference Standard for Service Equipment

UL 870 (2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings

UL 943 (2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters

UL 984 (1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors UL 1063 (2017) UL Standard for Safety Machine-Tool Wires and Cables

UL 1203 (2013; Reprint Mar 2021) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

UL 1242 (2006; Reprint Aug 2020) Standard for Electrical Intermediate Metal Conduit -- Steel

UL 1283 (2017) UL Standard for Safety Electromagnetic Interference Filters UL 1449 (2021) UL Standard for Safety Surge Protective Devices

UL 1561 (2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers

UL 1569 (2018) UL Standard for Safety Metal-Clad Cables UL 1660 (2019) Liquid-Tight Flexible Nonmetallic Conduit

UL 1699 (2017; Reprint Nov 2020) UL Standard for Safety Arc-Fault Circuit-Interrupters

UL 2043 (2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

UL 4248-1 (2017) UL Standard for Safety Fuseholders - Part 1: General Requirements

UL 4248-12 (2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval.

Submit the following in accordance with Section 01 33 00.

SD-02 Shop Drawings
Panelboards; G
Transformers; G
Busway; G
Cable trays; G
Motor control centers; 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. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Wireways; G

Load centers for housing units; G

Marking strips drawings; G

SD-03 Product Data
Receptacles; G

Circuit breakers; G
Switches; G
Transformers; G
Enclosed circuit breakers; G
Motor controllers; G
Combination motor controllers; G
Load centers for housing units; G
Manual motor starters; G
Residential load centers; G
Metering; G
Meter base only; G
CATV outlets; G
Telecommunications Grounding Busbar; G
Surge protective devices; G

Include performance and characteristic curves.

SD-06 Test Reports
600-volt wiring test; G
Grounding system test; G
Transformer tests; G
Ground-fault receptacle test;

SD-07 Certificates
Fuses; G

SD-09 Manufacturer's Field Reports
Transformer factory tests

SD-10 Operation and Maintenance Data
Electrical Systems, Data Package 5; G

1.4 QUALITY ASSURANCE

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

1.4.2 Regulatory Requirements
In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with 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 and:

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

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

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

1.4.3.1 Alternative Qualifications

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

1.4.3.2 Material and Equipment Manufacturing Date

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

1.5 MAINTENANCE

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. Include the following:

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

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

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

1.6 WARRANTY

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

1.7 SEISMIC REQUIREMENTS
Provide seismic details conforming to Section 13 48 73, 23 05 48.00 10 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and to Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

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

2.2 CONDUIT AND FITTINGS Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit
PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2, UL 651.

2.2.3 Intermediate Metal Conduit (IMC) UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT) UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit NEMA RN 1, Type 40 (1 mm 40 mils thick).

2.2.6 Flexible Metal Conduit
UL 1, limited to 1829 mm 6 feet.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel UL 360, limited to 1829 mm 6 feet.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit NEMA TC 3 for PVC and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit 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. Provide receptacles as specified herein, spaced a minimum of one every 455 mm
18 inches. Wire alternate receptacles on different circuits.

2.3.2 Surface Nonmetallic Raceway
UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet- type raceway with grounding-type receptacle where indicated.
Provide receptacles as specified herein, spaced a minimum of one every
455 mm 18inches.

2.4 BUSWAY

NEMA BU 1.1, UL 857. Provide the following:

a. Buses: copper.

b. Busways: rated [__] volts, [___] continuous current amperes, three- phase, four-wire, and include integral or internal ground bus or as indicated.

c. Short circuit rating: as indicated.

d. Busway systems: suitable for use indoors.

e. Enclosures: steel, metallic.

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

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

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

i. Internal barriers to prevent movement of superheated gases.

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

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

2.4.2 Plug-In Busways
Unventilated type. Provide the following:

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

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

2.5 CABLE TRAYS
NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal 100 mm 4 inch depth or as indicated.

b. Cable trays: constructed of steel that has been zinc-coated after fabrication.

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

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

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

f. Radius of bends: as indicated.

2.5.1 Basket-Type Cable Trays Provide size as indicated.

2.5.2 Trough-Type Cable Trays Provide size as indicated.

2.5.3 Ladder-Type Cable Trays Provide size as indicated.
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2.5.4 Channel-Type Cable Trays Provide size as indicated.

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2.5.5 Solid Bottom-Type Cable Trays Provide size as indicated.

2.6 OPEN TELECOMMUNICATIONS CABLE SUPPORT

2.6.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide open top cable supports as indicated.

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Provide Steel closed ring cable supports as indicated.

2.7 OUTLET BOXES AND COVERS

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

2.7.1 Floor Outlet Boxes Provide the following:

a. Boxes: nonadjustable and concrete tight.

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

c. Telecommunications outlets: consisting of flush, aluminum or stainless steel housing with a receptacle as specified and 25 mm 1 inch bushed side opening.

d. Receptacle outlets: consisting of flush aluminum or stainless steel housing with duplex-type receptacle as specified herein.

e. Provide gaskets where necessary to ensure watertight installation.

2.7.2 Outlet Boxes for Telecommunications System Provide the following:

a. Standard type 100 mm square by 54 mm deep 4 inches square by 2 1/8 inches deep.

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

c. Outlet boxes for fiber optic telecommunication outlets: include a minimum 10 mm 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum 27 mm 1 inch conduit system.

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

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

2.9.1 Conductors Provide the following:

a. Conductor shall be copper.

b. Conductors No. 10 AWG and larger diameter: stranded.

c. Conductors No. 12 AWG and smaller diameter: solid.

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

2.9.1.1 Equipment Manufacturer Requirements
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.

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

2.9.2.1 Ground and Neutral Conductors
Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: For 208/120V White; 480/277V Gray.

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

2.9.2.2 Ungrounded Conductors

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

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

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

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

2.9.3 Insulation

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

2.9.4 Bonding Conductors

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

2.9.4.1 Telecommunications Bonding Backbone (TBB)

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

2.9.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (TMGB) and the

electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

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

2.9.6 Nonmetallic Sheathed Cable 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
UL 1569; NFPA 70, Type MC cable.

2.9.9 Armored Cable
UL 4; NFPA 70, Type AC cable.

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

2.11 DEVICE PLATES Provide the following:

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

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

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

2.12 SWITCHES

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

a. Handles: white or ivory thermoplastic.

b. Wiring terminals: screw-type, side-wired.

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

alloy.

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

2.12.2 Switch with Red Pilot Handle NEMA WD 1. Provide the following:

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

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

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

d. The circuit's neutral conductor to each switch with a pilot light shall be derived from the same circuit that is being switched.

2.12.3 Breakers Used as Switches Breakers shall not be used as Switches.

2.12.4 Disconnect Switches
NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches.

Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor- disconnect means. Provide switches in NEMA 1 or 3R enclosure as indicated per NEMA ICS 6.

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

2.13.1 Fuseholders
Provide in accordance with UL 4248-1.

2.13.2 Cartridge Fuses, Current Limiting Type (Class R)
UL 198M, Class RK-1, RK-5, time-delay type. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.13.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)
UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.13.4 Cartridge Fuses, Current Limiting Type (Class T)
UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.14 RECEPTACLES
Provide the following:

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

b. Ratings and configurations: as indicated.

c. Bodies: white or ivory as per NEMA WD 1.

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

e. Dimensional requirements: per NEMA WD 6.

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

g. Grounding pole connected to mounting strap.

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

i. Receptacles shall be 20A commercial UL rated receptacles.

2.14.1 Switched Duplex Receptacles
Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.14.2 Weatherproof Receptacles

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

2.14.3 Ground-Fault Circuit Interrupter Receptacles
UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A ground-

fault circuit interrupter devices.
Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.14.4 Special Purpose Receptacles
Special purpose receptacles shall be provided with ratings and matching cord cap/plug.

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

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

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

2.14.8 Tamper-Resistant Receptacles
Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots in the areas specified in NEC article 406.12(1) through (7).

2.15 PANELBOARDS
Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated of 14,000 AIC minimum for 120/208V and 120/240V panelboards and 22,000 AIC minimum for 277/480V panelboards.

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

c. Panelboards: circuit breaker-equipped.

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

e. "Specific breaker placement" is required in panelboards to match

the breaker placement indicated in the panelboard schedule on the drawings.

f. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise.

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

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

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

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

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

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

m. Panelboard shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices.

2.15.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication.

c. Cabinets: painted in accordance with paragraph PAINTING.

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

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

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

g. Holes: provided in the back of indoor surface-mounted cabinets,

with outside spacers and inside stiffeners, for mounting the cabinets with a 15 mm 1/2 inch clear space between the back of the cabinet and the wall surface.

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

i. Each door: fitted with a combined catch and lock, except that doors over 600 mm 24 inches long provided with a three-point latch having a knob with a T- handle, and a cylinder lock.

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

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

2.15.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet. In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated. All panel busses must be copper.

2.15.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:

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

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

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

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

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

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

2.15.3 Circuit Breakers

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

2.15.3.1 Multipole Breakers

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

2.15.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with "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 ground-fault circuit interrupter.

2.15.3.3 Circuit Breakers for HVAC Equipment

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

2.15.3.4 Arc-Fault Circuit Interrupters

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

2.15.4 Fusible Switches for Panelboards

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

2.15.5 400 Hz Panelboard and Breakers

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

2.16 RESIDENTIAL LOAD CENTERS

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

a. UL 67 and UL 50.

b. RLCs for use as service disconnecting means: additionally

conform to UL 869A.

c. Circuit breaker equipped.

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

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

f. Provide printed directories reflecting unique circuit functions.

2.16.1 RLC Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated groundable neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.16.2 Circuit Breakers

UL 489, thermal magnetic-type with interrupting capacity as indicated of 14,000 AIC minimum for 120/208V and 120/240V panelboards and 22,000 AIC minimum for 277/480V panelboards. Breaker terminals: UL listed as suitable for the type of conductor provided.

2.16.2.1 Multipole Breakers

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

2.16.2.2 Circuit Breaker With Ground-Fault Circuit Interrupter

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 ground-fault circuit interrupter devices.

2.16.2.3 Arc-Fault Circuit-Interrupters

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

2.17 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

2.18 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

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

2.19 TRANSFORMERS

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated.

b. Provide transformers in NEMA 1 or 3R enclosure as indicated.

c. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

(2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 150 or 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

d. Transformer of 150 degrees C temperature rise: capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating.

e. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

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

2.20.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 115 degrees C or 150 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient

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

2.20.2 Transformers With Non-Linear Loads
Provide transformers for non-linear loads in accordance with the following:

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

b. For transformers greater than 112.5 KVA provide transformer insulation rating to mitigate increased fire rating of the space of which it is installed.

c. Transformers are to be UL listed and labeled for K-13 in accordance with UL 1561.

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

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

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

2.21 MOTORS
Provide motors in accordance with the following:

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

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

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

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

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

volts.

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

g. Unless otherwise indicated, use continuous duty type motors if rated 745 Watts 1 HP and above.

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

2.21.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: 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

Select polyphase motors 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 must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.21.3 Motor Sizes

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

2.21.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment forming part

of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.22 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

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

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

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

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

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

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

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

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

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

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

in sight from the motor location and the driven machinery location.

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

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

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

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

2.22.1 Control Wiring

Provide control wiring in accordance with the following:

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

b. Hinge wire: Class K stranding.

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

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

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

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

2.22.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

a. NEMA ICS 4.

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

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

d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.

e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four (4) spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.

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

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

2.22.2.1 Types of Terminal Blocks

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

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

2.22.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to UL 506, as applicable.

Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80

percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide one fused secondary lead with the other lead grounded. For designated systems, as indicated, provide backup power supply, including transformers connected to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit. Control circuits: maximum voltage of 120 volts derived from a separate control source. Provide terminals and terminal boards. Provide separate control disconnect switch within controller. Provide one fused secondary lead with the other lead grounded. For designated systems, as indicated, provide backup power supply, including connection to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.22.4 Enclosures for Motor Controllers NEMA ICS 6.

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

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

2.22.7 Pilot and Indicating Lights Provide LED cluster lamps.

2.23 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)
Three pole designed for surface mounting with overload protection and pilot lights.

2.23.1 Pilot Lights
Provide yoke-mounted, seven element LED cluster light module. Color: Green, red or amber in accordance with NEMA ICS 2.

2.24 MOTOR CONTROL CENTERS
Provide motor control centers in accordance with the following:

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

b. Wiring: Class I or II, Type A, B or C, in NEMA Type 1 or 3R enclosure.

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

withstand and interrupting rating
of[100,000][65,000][42,000][25,000][_] amperes rms symmetrical.

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

e. Main protective device: molded case circuit breaker or fusible switch rated at [] amperes rms symmetrical interrupting capacity.

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

g. Interconnecting wires: copper.

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

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

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

2.24.1.2 Vertical Bus
Vertical bus: Provide vertical bussing wherever possible, continuous current rating of [300][450][600][_____] amperes, and copper, silver-plated. Vertical bus: enclosed in flame-retardant, polyester glass “sandwich."

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

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

2.24.2 Combination Motor Controllers UL 508

2.24.3 Space Heaters

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

2.25 LOCKOUT REQUIREMENTS

Provide 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. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.26 TELECOMMUNICATIONS SYSTEM

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

2.27 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

Additional CATV requirements are specified in Section 27 54 00.00 20, COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS.

2.27.1 CATV Outlets

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

2.27.2 CATV Faceplates

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

2.27.3 Backboards

Provide void-free, fire rated interior grade plywood, 19 mm 3/4 inch thick, 1200 by 2400 mm, 4 by 8 feet or 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

2.28.1 Ground Rods

UL 467. Ground rods: copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.28.2. Ground Electrode Enhancement

UL listed carbon-based, maintenance-free enhancement. Bentonite-based material is not permitted.

2.28.2 Ground Bus

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

2.28.3 Telecommunications [and CATV]Grounding Busbar

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

a. Predrilled copper busbar provided with paired holes for use with standard sized bolt-lug combination.

b. Minimum dimensions of 0.25 inch thick by 4 inch wide for the TMGB with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.29 HAZARDOUS LOCATIONS

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

2.30 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the

manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.31 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

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

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

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

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

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

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

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

2.32 WARNING SIGNS

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

2.33 FIRESTOPPING MATERIALS

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

2.34 WIREWAYS

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

2.35 METERING
See JBLM Design Standards section 26 27 13.10 30 ELECTRIC METERS.

2.36 FACTORY APPLIED FINISH
Provide factory-applied finish on electrical equipment in accordance with the following:

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

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

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

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

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

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

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

2.39 SOURCE QUALITY CONTROL

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

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

PART 3 EXECUTION

3.1 INSTALLATION

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

3.1.1 Underground Service

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

3.1.2 Overhead Service

Overhead service conductors into buildings: terminate at service entrance fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in Section 33 71 01.00 40 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.1.3 Hazardous Locations

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

3.1.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such and only on one enclosure.

3.1.4.1 Labels

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

3.1.5 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment

grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size: 16 mm 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 150 mm 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00, FIRESTOPPING.

3.1.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 890-N 200-pound force tensile strength compatible with conduit material, such as woven nylon tape. Leave minimum 915 mm 36 inches of slack at each end of pull wire.

3.1.5.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable limited to last run between box and termination of lighting circuit.

3.1.5.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.1.5.4 Flat Conductor Cable

Install in accordance with NFPA 70, Type FCC cable.

3.1.6 Conduit Installation

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

3.1.6.1 Restrictions Applicable to Aluminum Conduit

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

b. Do not use brass or bronze fittings.

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

3.1.6.2 Restrictions Applicable to EMT

a. Do not install underground.

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

c. Do not use in areas subject to 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 in wet locations.

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).

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

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

floor.

3.1.6.6 Conduit Interior to Buildings for 400 Hz Circuits Nonmetallic. Where 400-Hz circuit runs underground or through concrete, provide PVC Schedule 40 or 80 conduit.

3.1.6.7 Conduit for Circuits Rated Greater Than 600 Volts Rigid metal conduit or IMC only.

3.1.6.8 Conduit Installed Under Floor Slabs
Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

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

3.1.6.10 Conduit Installed in Concrete Floor Slabs Rigid steel; steel IMC, or PVC, Type EPC-40 or 80. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum 25 mm one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than 27 mm one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

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

3.1.6.12 Conduit Support
Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by

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

3.1.6.13 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.6.14 Locknuts and Bushings

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

3.1.6.15 Flexible Connections

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

3.1.6.16 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

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

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

3.1.6.17 Community Antenna Television (CATV) System Conduits

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

3.1.7 Busway Installation

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

Provide supports to resist forces of
0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.8 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals or as indicated. Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 255 mm 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 103 mm 4 inch rigid steel conduits with grounding bushings, extending 305 mm 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support as indicated or at maximum 6 foot intervals. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607.

Ensure edges, fittings, and hardware are finished free from burrs and sharp edges. Provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section. 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

Install open top and closed ring cable supports on 1.2 m 4 ft to 1.5 m 5 ft centers to adequately support and distribute the cable’s weight. Use these types of supports to support a maximum of 50 6.4 mm 0.25 in diameter cables. Install suspended cables with at least 75 mm 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

3.1.10 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for

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

3.1.10.1 Boxes

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

3.1.10.2 Pull Boxes

Construct of at least minimum size required by NFPA 7 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

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 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets: mounted at height as indicated.

3.1.12 Nonmetallic Sheathed Cable Installation

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 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self- sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.13.1 Marking Strips

Provide marking strips in accordance with the following:

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

b. Use permanent ink for the wire numbers

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

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

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

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

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

3.1.14 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 Terminating Aluminum Conductors

3.1.15.1 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.

3.1.15.2 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.

3.1.16 Covers and Device Plates

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

3.1.17 Electrical Penetrations

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

3.1.18 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Bond 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, 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, where present. 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. Interconnect all grounding media in or on the structure to provide a common ground potential and made readily accessible.. This includes lightning protection, electrical service, telecommunications system bonding, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA- 607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.18.1 Ground Rods

Provide cone pointed ground rods. Measure the resistance to ground

using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, additional rods, spaced on center, not less than twice the distance of the length of the rod. In high- ground-resistance, UL listed carbon-enhanced ground electrodes 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 further measures required.

3.1.18.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required (such as test wells), 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 or insufficient slag 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. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

c. Reversible mechanical connections shall not be used.

3.1.18.3 Ground Bus

Provide a readily accessible copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to ground electrodes per NFPA 70 and as specified above having the upper ends terminating approximately 100 mm 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure- connector type, except use pressure connectors or bolted connections for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, provide a minimum of 4, one at each corner, ground buses connected to the building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and/or alterations. For connections to concrete-encased electrodes with exposure to earth, protect the conductor 6-inches within the concrete and 6-inches passed the concrete envelope to reduce corrosion risks.

3.1.18.4 Resistance

For facilities identified as a network node or otherwise per plan then a maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.18.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

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

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the TMGB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the TMGB extends throughout the building using the telecommunications backbone pathway, and connects to the TGBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB

conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a TGB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the TMGB or the TGB.

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

3.1.19 Equipment Connections

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

3.1.20 Elevator

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.

3.1.21 Government-Furnished Equipment

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

3.1.22 Repair of Existing Work

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

3.1.22.1 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. Workmanship quality assurance shall be at the discretion of the Authority Having Jurisdiction.

3.1.22.2 Existing Concealed Wiring to be Removed

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

3.1.22.3 Removal of Existing Electrical Distribution System

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

3.1.22.4 Continuation of Service

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

3.1.23 Watthour Meters ANSI C12.1.

3.1.24 Surge Protective Devices

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

3.2 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 with appropriate clearance from energized parts within.

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

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

3.5 FIELD QUALITY CONTROL

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

3.5.1 Devices Subject to Manual Operation

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

3.5.2 600-Volt Wiring Test

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

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 ground electrode system in part or

whole for resistance to earth before making connections to electrical service disconnect. 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 --