Preparing Activity: NASA Superseding
UFGS-26 23 00.00 40 (November 2014)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SWITCHBOARDS AND SWITCHGEAR
11/17

****

NOTE: This guide specification covers the requirements for free-standing, deadfront switchboard assemblies rated 6000 amperes or less, 600 volts or less, and metal-enclosed low-voltage power circuit breaker switchgear assemblies in either interior or exterior locations. Rename the section appropriately if this section is used to specify only switchboards or only switchgear. Use Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, for power and distribution panelboards rated 1200 amperes or less and consisting of only group-mounted, stationary, molded-case circuit breakers, and fusible or nonfusible switches designed to be placed in a cabinet or cutout box.

When the proposed switchboard or switchgear is connected to a secondary unit substation, coordinate with Section 26 11 16 SECONDARY UNIT SUBSTATIONS.

This guide specification is not intended to be used for generator control switchboards without extensive modification and coordination with applicable diesel engine-generator guide specifications.

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

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be

submitted as a Criteria Change Request (CCR).
****

****
NOTE: Ensure that the following information is indicated on the project drawings or specified in the project specifications:

1. Single-line diagram showing buses and interrupting devices with interrupting capacities; current transformers with ratings; instruments and meters required; and description of instruments and meters.

2. Location, space available, arrangement, and elevations of switchboards or switchgear.

3. Grounding plan.

4. Type and number of cables, size of conductors for each power circuit, and point of entry (top or bottom).

5. Special conditions, such as altitude, temperature and humidity, exposure to fumes, vapors, dust, and gases; and seismic requirements.
****

PART 1 GENERAL

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.1 PRODUCT COORDINATION

****
NOTE: When the project is designated to be designed to Antiterrorism Construction Standards, the electrical design addresses limiting critical infrastructure damage. If the project scope does not address special (Switchboard) (Switchgear) requirements, check with the Project Manager to see if, as a minimum, Seismic Zone 1 criteria should be incorporated.
****

Products and materials that are not considered to be[switchboards][or][switchgear] and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.2 REFERENCES

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

and title.

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

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

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to 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 A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2023) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)
ASTM D149	(2020) Dielectric Breakdown Voltage and

	Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building

and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA PB 2	(2011) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198M	(2018; Reprint May 2023) UL Standard for Mine-Duty Fuses
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2019) UL Standard for Safety Switchboards
UL 1558	(2016; Reprint Nov 2019) UL Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
UL 4248-12	(2018; Reprint Feb 2022) UL Standard for Safety Fuseholders - Part 12: Class R

1.3 DEFINITIONS

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

1.4 SUBMITTALS

****
NOTE: Choose between switchboards and switchgear in brackets throughout this specification. Modify appropriately if both are used in a job.
****

****
NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit

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

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

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

SD-02 Shop Drawings

[Switchboard][Switchgear] Drawings; G[, [____]]

SD-03 Product Data

[Switchboard][Switchgear]; G[, [____]]

Spare Parts List; G[, [____]]

SD-06 Test Reports

Acceptance Checks and Tests; G[, [____]]

SD-07 Certificates

Equipment Test Schedule

[Switchboard][Switchgear] Design Tests

[Switchboard][Switchgear] Production Tests

SD-10 Operation and Maintenance Data

[Switchboard][Switchgear] Operation and Maintenance, Data Package 5

SD-11 Closeout Submittals

Warranty

Assembled Operation and Maintenance Manuals

Request for Settings

1.5 QUALITY CONTROL

1.5.1 Predictive Testing And Inspection Technology Requirements

****
NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission-Essential. If the system is noncritical, nonconfigured, and not mission essential, use sound engineering discretion to assess the value of adding these test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.
****

This section addresses systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required in order to obtain Government approval and acceptance of the Contractor's work.

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

1.5.2 [Switchboard][Switchgear] Product Data

Include on each submittal the manufacturer's information for each component, device and accessory provided with the [switchboard][switchgear] including the following:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full-size logarithmic paper) of the main secondary breaker and

largest secondary feeder device

1.5.3 Regulatory Requirements

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

1.5.4 Standard Products

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

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are 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.

1.5.4.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years before the date of delivery to the site, unless specified otherwise.

1.6 WARRANTY

Provide the Contracting Officer with warranties associated with the equipment. Ensure that the equipment items are 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.

PART 2 PRODUCTS

2.1 DESIGN REQUIREMENTS

Show wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items to ensure a coordinated installation.

2.1.1 [Switchboard][Switchgear] Drawings

Drawings include the following:

a. One-line diagram, including breakers[, fuses][, current transformers, and meters]

b. Outline drawings, including front elevation, section views, footprint, and overall dimensions

c. Bus configuration, including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data[, including fuse information (manufacturer's name, catalog number, and ratings)]

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams, elementary diagrams, and wiring diagrams. with terminals identified and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full-size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

[h. Provisions for future extension.

]2.1.2 Ratings

The voltage rating of the [switchboard][switchgear] is [480Y/277][208Y/120][125][_____] volts [AC][DC], [2][3][4]-wire [[single][3] phase][as indicated]. The continuous-current rating of the main bus is [[_____] amperes][as indicated]. The short-circuit current rating is [[_____] RMS symmetrical amperes][as indicated]. Provide a [switchboard][switchgear] that is UL-listed and labeled[for its intended use][as service entrance equipment].

2.2 COMPONENTS

Provide[SWITCHBOARD][SWITCHGEAR] that conforms to [NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558].

2.2.1 Construction

****

NOTES: The switchboard specified below is not intended for applications where the available fault current is above 65,000 amps. Where drawout breakers, and high short-circuit current ratings are desired, use UFGS Section 26 22 00.00 10 480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS.

Ensure that the short-circuit current rating assigned to the switchboard is in accordance with NEMA PB 2.

****

[Provide dead front switchboards conforming to NEMA PB 2 and labeled under UL 891. Ensure that the switchboards are completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, [and other devices] as shown on the drawings. Provide switchboards that are fully rated for a

short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

] [Switchboard][Switchgear] consists of vertical sections bolted together to form a rigid assembly and is [rear-][front- and rear-] aligned[as indicated]. All circuit breakers are front-accessible.[Rear-aligned switchboards have front-accessible load connections.][Front- and rear-aligned switchboards have rear-accessible load connections.][Ensure that compartmentalized [switchboards have][switchgear has] vertical insulating barriers between the front device section, the main bus section, and the cable compartment[with full front-to-rear vertical insulating barriers between adjacent sections].] Where indicated, "space for future" or "space" means to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm (0.25 inch) 0.25 inch minimum thickness. Apply moisture-resistant coating to all rough-cut edges of barriers. Provide a switchboard that is completely factory-engineered and factory-assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.1.1 Enclosure

****

NOTE: Choose the level of corrosion protection required for the specific project location. Use galvanized steel in most indoor applications. Use stainless-steel bases for most outdoor applications. In less corrosive environments, galvanized steel can be included as an alternative to stainless-steel. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments.

In the last sentence, use IEEE C57.12.28 for galvanized enclosures. Use IEEE C57.12.29 for stainless-steel enclosures.

****

Ensure that the [switchboard][switchgear] enclosure is [an outdoor] NEMA ICS 6 Type [3R][1][_____][as indicated][fabricated entirely of 12-gauge ASTM A240/A240M type 304 or 304L stainless-steel]. Bolt the enclosure together with removable bolt-on side and[hinged] rear covers[, and slope the roof downward toward the rear].[Provide front[and rear] doors with[stainless-steel] padlockable vault handles with a three-point catch.] Ensure that bases, frames and channels of enclosure are corrosion resistant and fabricated of[ASTM A240/A240M type 304 or 304L stainless-steel][or][galvanized steel]. Base includes any part of enclosure that is within 75 mm 3 inches of concrete pad.[Galvanized steel conforms to ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.] Paint the enclosure, including the bases, ASTM D1535 light gray No. 61 or No. 49. Ensure that the paint coating system complies with[IEEE C57.12.28 for galvanized steel][and][IEEE C57.12.29 for stainless-steel].

****

NOTE: Include mounting sills for all new construction to provide structural integrity. NEMA PB2 90 inch height includes these sills.

****

[Provide a NEMA Type [2] [3R] switchboard enclosure, built with selected smooth sheet steel panels of not less than 1.9 mm No. 14 gage. Ensure that the exposed panels on the front and ends have bent-angle or channel edges with all corner seams welded and ground smooth. Ensure that the front outside surfaces are not drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings are visible from the front. Make the front panels in sections, flanged on four sides and attached to the framework by screws, and arranged for ready removal for inspection or maintenance. [Provide rear access to the bus and device connections.]Provide grille ventilating openings. Provide all ventilating openings with corrosion-resistant insectproof screens on the inside. [Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base.][Mount switchboards as shown on the drawings and furnish mounting materials as indicated.]Treat all interior and exterior steel parts to inhibit corrosion and paint the enclosure .

]2.2.1.2 Bus Bars

****

NOTE: Use copper with silver-plated contact surfaces in exterior or damp locations or for heavy motor loads.

Only choose the bracketed option requiring epoxy coating on the bus bars for outdoor locations with a high concentration of airborne contaminants. Choose this option primarily for outdoor waterfront or dirty industrial applications.

****

[Ensure that the bus bars are[copper with silver-plated contact surfaces][or][aluminum with tin-plated contact surfaces]. Ensure that plating is at least 0.005 mm 0.0002 inches thick. Make bus connections and joints with hardened-steel bolts. Rate the through-bus at the full ampacity of the main throughout the switchboard. Provide a copper ground bus at least 6.35 mm by 50.8 mm 0.25 inch by 2 inches secured to each vertical section along the entire length of the [switchboard][switchgear]. Rate the neutral bus [100][_____] percent of the main bus continuous-current rating[as indicated].[Insulate bus bars with an epoxy finish coating powder providing a minimum breakdown voltage of 16,000 volts in accordance with ASTM D149.]
]

****

NOTE: When either copper or aluminum bus is allowed, the manufacturers will generally provide the less expensive aluminum. Use ASTM 317 when aluminum bus is permitted. Silver plating allows for a greater temperature rise on the bus.

****

[Ensure that all buses are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] are tin-plated or silver-plated [throughout]. Ensure that copper [or aluminum] bars and shapes for bus conductors conform to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. Bolt all splices

for field assembly with at least two bolts, and employ the use of "Belleville" washers in the connection. Ensure that horizontal and vertical power buses have the minimum current ratings shown on the drawings. Insulate buses for not less than 600 volts. Braze, pressure-weld, or bolt, splices and tap connections. Bolt the splices for field assembly. Mount the buses on insulating supports of wet-process porcelain, glass polyester, or suitable molded material, and brace to withstand not less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac. Near the bottom of the enclosure, mount a copper [or aluminum] ground bus, rated not less than 300 amperes, extending the entire length of the assembled structure. Provide a full-clamp solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

]2.2.1.3 Main Section

The main section consists of[main lugs only][an individually mounted[drawout][air power circuit breaker[with current-limiting fuses]][insulated-case circuit breaker][molded-case circuit breaker][bolted pressure switch][fusible switch]][and utility transformer compartment].

2.2.1.4 Distribution Sections

The distribution section[s] consist of[[individually mounted,][drawout,]][air power circuit breakers[with current-limiting fuses]][insulated-case circuit breakers][molded-case circuit breakers][bolted pressure switches][fusible switches][and utility transformer compartments] as indicated.

[2.2.1.5 Combination Sections

Combination sections consist of[molded-case circuit breakers][fusible switches] for the[main and] branch devices as indicated.

][2.2.1.6 Auxiliary Sections

Auxiliary sections consist of indicated[instruments,][metering equipment,][control equipment,][transformer,][and][current transformer compartments] as indicated.

][2.2.1.7 Handles

Ensure that handles for individually mounted devices are of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color-coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

]2.2.2 Protective Device

****

NOTE: Place switchboards where the ambient temperature is less than 40 degrees C 104 degrees F. However, should the ambient temperature be expected to exceed 40 degrees C 104 degrees F, call for special calibration for the circuit breakers.

Provide ground fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground for each service disconnect

rated 1000 amperes or more in accordance with NFPA 70.

If 48 Vdc or 125 Vdc electrically operated circuit breakers are required, add the appropriate DC control power supply information to the specification. Reference information can be obtained from Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION.

****

Provide[main and] branch protective devices as indicated.

[2.2.2.1 Power Circuit Breaker

Provide breakers conforming to IEEE C37.13. Provide [120 Vac][electrically][manually] operated [stationary][drawout], [unfused][fused],[steel frame,] low-voltage power circuit breaker with a short-circuit current rating[of [_____] RMS amperes symmetrical][as indicated] at [_____] volts. The breaker frame size is[as indicated][[_____] amperes].[Equip the electrically operated breakers with a motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.]

][2.2.2.2 Insulated-Case Breaker

Provide a UL-listed, 100-percent rated,[stationary][drawout],[120 Vac],[electrically] [manually] operated, low-voltage, insulated-case circuit breaker, with a short-circuit current rating[of [_____] RMS symmetrical amperes][as indicated] at [_____] volts. The breaker frame size is [[_____] amperes][as indicated].[Equip the electrically operated breaker with a motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.]

][2.2.2.3 Molded-Case Circuit Breaker

Provide breakers conforming to UL 489. Ensure that breakers are UL-listed and labeled, 100-percent rated,[stationary][drawout],[120 Vac],[electrically][manually] operated, low-voltage molded-case circuit breaker, with a short-circuit current rating of[[_____] RMS symmetrical amperes][as indicated] at [_____] volts. Breaker frame size is [[_____] amperes][as indicated]. Series-rated circuit breakers are unacceptable.

[Equip each switchboard with molded-case circuit breakers with trip ratings and terminal connectors for attachment of outgoing power cables as shown on the drawings. Ensure that the circuit breakers are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments.

]][2.2.2.4 Fusible Switches

Provide quick-make, quick-break, hinged-door fusible switches.[Ensure that the switches serving as motor disconnects are horsepower-rated.] Ensure that the fuses have current-limiting cartridges conforming to[UL 198M, Class J for 0 to 600 amperes and Class L for 601 to 6000

amperes][UL 198M, Class [RK1][RK5] for 0 to 600 amperes].

Ensure that fuseholders conform to UL 4248-12.

][2.2.2.5 Integral Combination Breaker and Current-Limiting Fuses

Provide fuses conforming to UL 489. Provide integral combination molded-case circuit breaker and current-limiting fuses[as indicated][rated [_____] amperes] with a minimum short-circuit current rating equal to the short-circuit current rating of the [switchboard][switchgear] in which the circuit breaker is mounted. Series-rated circuit breakers are unacceptable. Ensure that overcurrent devices of the circuit breaker and current-limiting fuses are coordinated such that on overloads or fault currents of relatively low value, the overcurrent device of the breaker is operated to clear the fault. For high-magnitude short circuits above a predetermined value[crossover point], ensure that the current-limiting fuses operate to clear the fault. Ensure that the housing for the current-limiting fuses is an individual molding readily removable from the front and located at the load side of the circuit breaker. If the fuse housing is removed, ensure that a blown fuse is readily evident by means of a visible indicator. Ensure that the removal of the fuse housing causes the breaker contacts to open, and that it is not possible to close the breaker contacts with the fuse housing removed. Ensure that it is not possible to insert the fuse housing with a blown fuse or with one fuse missing. Ensure that the the blowing of any of the fuses causes the circuit breaker contacts to open.

][2.2.3 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. Ensure that the main, auxiliary, and control disconnecting contacts are silver-plated, multifinger, positive-pressure, and self-aligning. Provide each drawout breaker with four-position operation. Clearly identify each position by an indicator on the circuit breaker front panel.

a. Connected Position: Primary and secondary contacts are fully engaged. Ensure that the breaker is tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but the secondary contacts remain fully engaged. Ensure that the position allows complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker actuates the assembly that isolates the primary stabs.

][2.2.4 Electronic Trip Units

Equip[main and][distribution] breakers[as indicated] with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true RMS-sensing adjustable time-current circuit protection. The ampere rating of the current sensors are [as indicated][[_____] amperes][the same as the breaker frame

rating]. The trip unit ampere rating is[as indicated][[_____] amperes].[Ground fault protection is[as indicated][zero-sequence sensing][residual-sensing].][Provide the electronic trip units with the following features[as indicated].]

****

NOTE: In the items below, choose the bracketed item "main" when the item applies only to the main breaker.

Provide ground fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground for each service disconnect rated 1000 amperes or more in accordance with NFPA 70.

****

[a. [Indicated breakers]Breakers have long-delay pickup and time settings, and LED indication of cause of circuit breaker trip.

][b. Main breakers have[short-delay pickup and time settings][and][, instantaneous settings][and][ground fault settings][as indicated].

][c. Distribution breakers have[short-delay pickup and time settings][, instantaneous settings][, and ground fault settings][as indicated].

][d. [Main]Breakers have a digital display for phase and ground current.

][e. [Main]Breakers have a digital display for watts(W), volt-amperes (VA), kilovolt-ampere hours (kVAh) volt-amperes reactive (VAr), kilovolt-ampere reactive hours (kVArh), and kilowatt hoursvars, VA, (kWh).

][f. [Main]Breakers have a digital display for phase voltage, and percentage total harmonic distortion (THD) voltage and current.

][g. [Main]Breakers have provisions for communication via a network twisted-pair cable for remote monitoring and control.

]][2.2.5 Electronic Trip Unit Central Monitor

Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. Ensure that the central monitor has the following features:

a. Alphanumeric display

b. Indication of circuit breaker status: tripped, open, closed

c. Cause of circuit breaker trip

d. Phase, neutral, and ground current for each breaker

e. Energy parameters for each breaker

f. Provisions for communicating directly to a remote computer

][2.2.6 Instruments

Provide electrical indicating switchboard instruments, with 2-percent accuracy. Provide ac ammeters and voltmeters at least 50.8 mm square 2 inches square, with a 250-degree scale. Provide single-phase indicating instruments with flush-mounted transfer switches for reading three phases.

[2.2.6.1 AC Ammeters

Provide a [self-contained,][transformer-rated, 5-ampere input ac ammeter, for use with a [_____] to 5-ampere current transformer ratio,]0-to-[_____]-ampere scale range, 60 hertz.

][2.2.6.2 AC Voltmeters

Provide self-contained voltmeters.

][2.2.6.3 Instrument Control Switches

Provide rotary cam-operated instrument control switches with positive means of indicating contact positions. Ensure that switches have silver-to-silver contacts enclosed in a protective cover that can be removed to inspect the contacts.

]][2.2.7 Watthour and Digital Meters

****
NOTE: When Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC is used, coordinate meter requirements. Form 9S, in text below, is for three-phase, four-wire wye systems; for other system configurations, the designer determines the appropriate form designation.
****

[2.2.7.1 Digital Meters

****
NOTE: Digital metering incorporates the latest technology and provides additional information, often without additional cost. A control power transformer (115 V or 130 V) is normally required with this type of metering.
****

Ensure that meters conform to IEEE C37.90.1 for surge-withstand requirements. Provide true RMS, plus/minus 1-percent accuracy, programmable, microprocessor-based meters enclosed in sealed cases with a simultaneous 3-line, 12-value LED display. Ensure that meters have 16 mm) 0.56-inch, minimum, LEDs.[Watthour meters have 16 mm 0.56-inch, minimum, LEDs.] Ensure that the meters accept[input from standard 5A secondary instrument transformers][and][direct-voltage monitoring range to [300][600] volts, phase to phase]. Ensure the programming is via a front-panel display and a communication interface with a computer. Store password-secured programming in nonvolatile EEPROM memory. Ensure that digital communications are Modbus [ASCII][RTU] protocol via a [RS232C][RS485] serial port[and an independently addressable [RS232C][RS485] serial port]. Ensure that the meter calculates and stores average max/min demand values for all readings based on a user-selectable

sliding-window averaging period. Ensure that the meter has programmable high/low set limits with two Form C dry-contact relays when exceeding alarm conditions.[Provide a meter with THD measurement to the thirty-first order.][Ensure that the historical-trend logging capability can to store up to [100,000] [_____] data points with intervals of 1 second to 180 minutes. Ensure that the unit can also store and time-stamp up to 100 programmable triggered conditions.][Ensure that event waveform recording is triggered by the RMS of two cycles of voltage or current exceeding programmable set points. Ensure that the meter stores waveforms for all six channels of voltage and current for a minimum of 10 cycles before the event and 50 cycles past the event.]

[a. Multifunction Meter: Meter simultaneously displays a selected phase-to-neutral voltage, phase-to-phase voltage, percent phase-to-neutral voltage THD, percentage phase-to-phase voltage THD; a selected phase current, neutral current, percent phase current THD, percentage neutral current; and selected total picofarad (PF), kW, kVA, kVAr, frequency (FREQ), kVAh, and kWh. Detected alarm conditions include over/under current, over/under voltage, over/under kVA, over/under frequency, over/under selected PF/kVAr, voltage phase reversal, voltage imbalance, reverse power, and over percentage THD. Ensure that the meter has a Form C KYZ pulse output relay.

][b. Power Meter: Meter simultaneously displays watts (W), VAr, and selected kVA/PF. Detected alarm conditions include over/under kVA, over/under PF, over/under VAr, and over/under reverse power.

][c. Voltmeter: Meter is selectable between simultaneous display of the three phases of phase-to-neutral voltages and simultaneous display of the three phases of the phase-to-phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, and over percentage THD.

][d. Ammeter: Meter simultaneously displays phase A, B, and C currents. Detected alarm conditions include over/under current and over percentage THD.

][e. Digital Watthour Meter: Meter has a single selectable display for W, total kWh and watt demand (Wd). The meter has a Form C KYZ pulse output relay.

]][2.2.7.2 Electronic Watthour Meter

Provide a switchboard-style electronic programmable watthour meter, semi-drawout, semiflush-mounted, as indicated. Meter is either programmed at the factory or programmed in the field. After field programming is complete, turn the field programming device over to the Contracting Officer.

a. Design: Provide a meter designed for use on a 3-phase, 4-wire, [208Y/120][480Y/277] volt system with three current transformers. Include the necessary KYZ pulse initiation hardware for the Energy Monitoring and Control System (EMCS)[as specified in[Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC]].

b. Coordination: Provide a meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Form: [9S][___]. Accuracy: plus/minus 1.0 percent.

Finish: Class II.

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

e. Demand Register:

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

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

f. Meter fusing: Provide a fuse block-mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

]]2.2.8 Current Transformers

****

NOTE: Select the appropriate current transformer ratio, continuous-thermal-current rating factor (RF) at 30 degrees C 86 degrees F and ANSI Metering Accuracy Class values based on the current transformer ratio that is just below the rating of the main protective device.

Select an ANSI metering accuracy class in accordance with the current transformer (CT) ratios and rating factors (RFs) in the following table:

CT Ratio	RF	Accuracy Class
200/5	4.0	0.3 through B-0.1
300/5	3.0	0.3 through B-0.2
400/5	4.0	0.3 through B-0.2
600/5	3.0	0.3 through B-0.5
800/5	2.0	0.3 through B-0.5
1200/5	1.5	0.3 through B-0.5
1500/5	1.5	0.3 through B-0.9
2000/5	1.5	0.3 through B-1.8

****

Provide transformers that conform to IEEE C57.13. Ensure that transformers are single-ratio, 60 hertz, [_____] to 5-ampere ratio, [_____] rating factor, with a metering accuracy class of 0.3 through [_____].

[2.2.9 Transformer

****

NOTE: Coordinate with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, when transformer section is provided. Use UL 891 for switchboards and UL 1558 for switchgear.

****

Provide transformer section in [switchboard][switchgear] in accordance with [UL 891][UL 1558] and as indicated. Ensure that the transformer and section are suitable for the installation.[Test transformers greater

than 10 kVA in accordance with UL 891.] Ensure that transformers conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

][2.2.10 Meter Fusing

Provide a fuse block-mounted in the metering compartment, containing one fuse per phase to protect the voltage input to voltage sensing meters. Size the fuses as recommended by the meter manufacturer.

][2.2.11 Heaters

Provide 120-volt heaters in each [switchboard][switchgear] section. Provide heaters that can control moisture condensation in the section, are a minimum 250 watts, and are controlled by a thermostat[and humidistat] located in the section. Provide an industrial, high-limit thermostat to maintain sections within the range of 15 to 32 degrees C 60 to 90 degrees F.[Humidistat has a range of 30 to 60 percent relative humidity.] Obtain supply voltage for the heaters from a control power transformer within the [switchboard][switchgear]. If heater voltage is different from switchboard voltage, provide a transformer rated to carry 125 percent of heater full-load rating. Ensure that the transformer has a 220-degrees C insulation system with a temperature rise not exceeding 115 degrees C and conforms to IEEE C57.12.01.[Energize electric heaters in the switchboard assemblies while the equipment is in storage or in place before the heaters are placed in service. Provide a method to easily connect the heater to an external power source. Provide reliable, temporary, external power source if the commercial power at the rated voltage is not available on site.]

]2.2.12 Terminal Boards

Provide terminal boards with engraved plastic terminal strips and screw terminals for external wiring between components and for internal wiring between removable assemblies. Ensure that the terminal boards associated with current transformers are short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Ensure that the terminal board identification is identical in similar units. Color-code external wiring consistently for similar terminal boards.

2.2.13 Wire Marking

Mark the control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat-stamped with black block letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat-stamped with black block letters. Ensure that each sleeve contains a single letter or number, is elliptically shaped to securely grip the wire, and is keyed to align with the adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Ensure that each wire marker indicates the device or equipment, including the specific terminal number to which the remote end of the wire is attached.

2.2.14 Manufacturer's Nameplate

Ensure that each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number, securely affixed in a conspicuous place. The nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.2.15 Field-Fabricated Nameplates

****
NOTE: Use the bracketed sentence to specify labels for switchboards or switchgear where emergency breakers are located within the switchboards or switchgear. Provide a note on the drawings to indicate where red labels are required.
****

Ensure that nameplates conform to ASTM D709. Provide laminated plastic nameplates for each[switchboard,][switchgear,] equipment enclosure, relay, switch, and device, as specified in this section or as indicated on the drawings. Ensure that each nameplate inscription identifies the function and, when applicable, the position. Construct the nameplates of melamine plastic, 3 mm 0.125 inch thick, white with [black][_____] center core.[Provide a red laminated plastic label with a white center core where indicated.] Provide a matte finish with square corners. Accurately align lettering and engrave into the core. Ensure that nameplates measure at least 25.4 by 63.5 mm 1 inch by 2.5 inches. Provide block lettering at least 6.35 mm 0.25 inch high.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide schedules for equipment to be tested at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before the scheduled test date. Notify the Contracting Officer 15 calendar days before changes to the scheduled test date.

a. Test Instrument Calibration Requirements

(1) The manufacturer has a calibration program ensuring that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy is directly traceable to the National Institute of Standards and Technology.

(3) The instrument calibration frequency schedule cannot exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels are visible on all test equipment.

(5) The calibrating standard is of higher accuracy than that of the instrument tested.

(6) Records that indicate dates and test results of instruments calibrated or tested are kept up to date. For instruments calibrated by the manufacturer on a routine basis, in lieu of third-party calibration, the following are included:

(a) Up-to-date instrument calibration instructions and procedures for each test instrument

(b) Identification of instruments calibrated by a third party or

laboratory to verify that the calibrating standard is met

2.3.2 [Switchboard][Switchgear] Design Tests

****
NOTE: Use the first bracketed option for switchboards and the second bracketed option for switchgear.
****

[NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558].

2.3.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test

b. Enclosure tests

c. Dielectric test

[2.3.2.2 Additional Design Tests

****
NOTE: Include additional design tests when the switchboard or switchgear main bus is rated greater than 4000 amperes.
****

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports that include results of design tests performed on the actual equipment.

a. Temperature rise tests

b. Continuous current

]2.3.3 [Switchboard][Switchgear] Production Tests

****
NOTE: Use the first bracketed option for switchboards and the second bracketed option for switchgear.
****

[NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558]. Furnish reports that include results of production tests performed on the actual equipment for this project. These tests include the following:

a. 60-hertz dielectric tests

b. Mechanical operation tests

c. Electrical operation and control wiring tests

d. Ground fault sensing equipment test

2.4 COORDINATED POWER SYSTEM PROTECTION

****

NOTE: Use this paragraph only for Army projects.

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

****

Provide a power system study as specified in Section 26 05 73 COORDINATED POWER SYSTEM STUDIES.

PART 3 EXECUTION

3.1 INSTALLATION

Ensure that the electrical installations conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Grounding

****

NOTE: Where rock or other soil conditions prevent obtaining a specified ground value, specify other methods of grounding. Where it is impractical to obtain the indicated ground resistance values, make every effort to obtain ground resistance values as near as possible to the indicated values.

****

Meet the requirements of NFPA 70 and IEEE C2, except that grounds and grounding systems have a resistance to solid earth ground not exceeding 5 ohms.

3.1.1.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at the equipment end of the ground conductors.

3.1.1.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG and not less than 610 mm 24-inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed in order to obtain the specified ground resistance, the provision of the Contract covering "Changes" applies.

3.1.1.3 Connections

Make the joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph GROUNDING CONNECTIONS.

3.1.1.4 Grounding and Bonding Equipment

Ensure that the equipment conforms to UL 467, except as indicated or otherwise specified.

3.1.2 Installation of Equipment and Assemblies

Install and connect equipment furnished under this section as indicated on approved project or shop drawings and as specified herein.

3.1.2.1 [Switchboard

ANSI/NEMA PB 2.1.

]3.1.2.2 [Switchgear

IEEE C37.20.1A.

]3.1.2.3 [Meters and Instrument Transformers

ANSI C12.1.

]3.1.2.4 Field-Applied Painting

Where field painting of enclosures is necessary to correct damage to the manufacturer's factory-applied coatings, provide the manufacturer's recommended coatings and apply in accordance with the manufacturer's instructions.

3.1.2.5 Galvanizing Repair

Repair damage to galvanized coatings in conformance with ASTM A780/A780M, using zinc-rich paint, for galvanizing surfaces damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that the repair paint has been applied to.

3.1.2.6 Field-Fabricated Nameplate Mounting

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

3.1.3 Foundation For Equipment And Assemblies

****

NOTE: Mounting-slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings.

****

3.1.3.1 Exterior Location

Mount the [switchboard][switchgear] on a concrete slab. Unless otherwise indicated, ensure that the slab is at least 200 mm 8 inches thick, reinforced with a 150 by 150 mm 6 inch by 6 inch No. 6 mesh placed uniformly 100 mm 4 inchesfrom the top of the slab. Place the slab on a 150 mm 6 inch thick, well-compacted gravel base. Set the top of the concrete slab approximately 100 mm 4 inches above the finished grade. Form the edges above grade to have a 15 mm 0.5 inch chamfer. Ensure that the slab projects at least 200 mm 8 inches beyond the equipment. Provide conduit turn-ups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in the slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3 inches above the slab surface. Ensure that concrete work is as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.1.3.2 Interior Location

Mount the [switchboard][switchgear] on the concrete slab. Unless otherwise indicated, ensure that the slab is at least 100 mm 4 inches thick. Place the top of the concrete slab approximately 100 mm 4 inches above the finished floor. Form edges above the floor to have a 15 mm 0.5 inch chamfer. Size the slab to project at least 100 mm 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in the slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3 inches above the slab surface. Ensure that concrete work is as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2 FIELD QUALITY CONTROL

Submit a request for settings of breakers to the Contracting Officer after approval of the [switchboard][switchgear] and at least 30 days before their requirement.

3.2.1 Performance of Acceptance Checks and Tests

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

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

Perform tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

[3.2.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage, required area clearances, and correct alignment.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.

[(7) Verify that current transformer ratios correspond to approved shop drawings.

] (8) Inspect all bolted electrical connections for high resistance using a low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Clean switchboard.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier[and shutter] installation[and operation].

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that vents are clear.

(16) Test the operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform overpotential tests.

(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

[(6) Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.

][(7) Verify operation of switchboard heaters.

]][3.2.1.2 Switchgear

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage, required area clearances, and correct alignment.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.

[(7) Verify that current transformer ratios correspond to approved shop drawings.

] (8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method or performing a thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Clean switchgear.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier[and shutter] installation[and operation].

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that vents are clear.

(16) Test the operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform overpotential tests.

(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

[(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

][(7) Verify operation of switchgear heaters.

]]3.2.1.3 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.

(5) Verify that all maintenance devices are available for servicing and operating the breaker.

(6) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(7) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(9) Verify cell fit and element alignment.

(10) Verify racking mechanism.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust breakers for final settings in accordance with Government-provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

****
NOTE: Coordinate each option with each breaker type.
****

[(6) Determine short-time pickup and delay by primary current injection.

][(7) Determine ground fault pickup and delay by primary current injection.

][(8) Determine instantaneous pickup value by primary current injection.

][(9) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure the operation of shunt trip devices; check the operation of electrically operated breakers in their cubicle.

] (10) Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.2.1.4 Circuit Breakers

[Low-Voltage - Insulated-Case][and][Low-Voltage Molded-Case with Solid-State Trips

] a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to verify smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted connections or cable connections by using the calibrated torque-wrench method or performing a thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform breaker adjustments for final settings in accordance with Government-provided settings.

(4) Perform long-time-delay time-current characteristic tests.

****
NOTE: Coordinate each option with each breaker type.
****

[(5) Determine short-time pickup and delay by primary current injection.

][(6) Determine ground fault pickup and time delay by primary current injection.

][(7) Determine instantaneous pickup current by primary injection.

][(8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

]3.2.1.5 Current Transformers (CTs)

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.2.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to the manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.2.1.7 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform tests in conformance with IEEE 81. Measure ground impedance, using the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with the manufacturer's instructions to test each ground or group of grounds. Ensure that the instrument is equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (that is, pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.2.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Testing requires each item to perform its function not less than three times. Submit test results to the Contacting Officer. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer of the dates and times for checks, settings, and tests 5 working days in advance.

3.3 CLOSEOUT ACTIVITIES

3.3.1 [Switchboard][Switchgear] Operation and Maintenance Data

Submit operation and maintenance manuals in accordance with Section 01 78 23OPERATION AND MAINTENANCE DATA.

3.3.2 Assembled Operation and Maintenance Manuals

Assemble and bind manuals securely in durable, hard-covered, water-resistant binders. Assemble and index the manuals in the following order with a table of contents

a. Manufacturer's O&M information required by paragraph SD-10 OPERATION AND MAINTENANCE DATA

b. Catalog data required by paragraph SD-03 PRODUCT DATA

c. Drawings required by paragraph SD-02 SHOP DRAWINGS

d. Prices for spare parts and supply list

[e. Information on metering

] f. Design test reports

g. Production test reports

[3.3.3 Spare Parts List

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NOTE: Spare parts are specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA for Navy projects. Do not use this paragraph for Navy projects.

Edit as required if additional spare parts are required for a specific project.
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Furnish a list of spare parts.

] -- End of Section --