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DIVISION 26 - ELECTRICAL

SECTION 26 23 00.00 40

SWITCHBOARDS AND SWITCHGEAR

11/14

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

Products and materials 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 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.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2011) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)
ASTM D149	(2009; R 2013) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D1535	(2013) Specifying Color by the Munsell System
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C37.13	(2008; INT 1 2009; AMD 1 2012) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1	(2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.90.1	(2012) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.01	(2005) 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	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
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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 C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
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UNDERWRITERS LABORATORIES (UL)

UL 1558	(1999; Reprint Apr 2010) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 4248-12	(2007; Reprint Dec 2012) UL Standard for Safety Fuseholders - Part 12: Class R
UL 467	(2007) Grounding and Bonding Equipment
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, use 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 to reflect only the submittals required for the project.

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

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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

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

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

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

SD-10 Operation and Maintenance Data

[Switchboard][Switchgear] Operation and Maintenance, Data Package
5[; G[, [____]]]

SD-11 Closeout Submittals

Warranty[; G[, [____]]]

Assembled Operation and Maintenance Manuals[; G[, [____]]]

Equipment Test Schedule[; G[, [____]]]

Request for Settings[; G[, [____]]]

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 [Switchboard][Switchgear] Operation and Maintenance Data

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

1.5.2 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. The contents of the assembled operation and
maintenance manuals are as follows:

- a. Manufacturer's O&M information required by the paragraph entitled,
"SD-10, Operation and Maintenance Data."
- b. Catalog data required by the paragraph entitled, "SD-03, Product Data".
- c. Drawings required by the paragraph entitled, "SD-02, Shop Drawings".
- d. Prices for spare parts and supply list.
- [e. Information on metering
-] f. Design test reports
- g. Production test reports

[1.5.3 Spare Parts List

**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.

Furnish a list of spare parts.

1.6 QUALITY CONTROL

1.6.1 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 non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional 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 contains systems and/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 building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required 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.

1.6.2 [Switchboard][Switchgear] Product Data

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

- 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.

1.6.3 [Switchboard][Switchgear] Drawings

Drawings include, but are not limited to 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 and 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.

1.6.4 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 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.

1.6.5 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. Ensure products have been in satisfactory commercial or industrial use for 2-years prior to 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.

1.6.5.1 Alternative Qualifications

Products having less than a two-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.

1.6.5.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than three-years prior to date of delivery to site, unless specified otherwise.

1.7 WARRANTY

Provide the Contracting Officer with warranties associated with the equipment. Ensure the equipment items are supported by service

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

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 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]. The [switchboard][switchgear] 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 C37.20.1 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-type breakers, and high short circuit current ratings are desired, UFGS Section 26 22 00.00 10 480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS should be used.

Ensure 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 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. Ensure switchboards 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 compartmentalized [switchboards][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 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 non-coastal and non-corrosive environments.

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

The [switchboard][switchgear] enclosure is a[outdoor] NEMA ICS 6 Type [3R][1][____][as indicated][fabricated entirely of 12 gauge ASTM A240/A240M type 304 or 304L stainless steel]. Bolt enclosure together with removable bolt-on side and[hinged] rear covers[, and sloping roof downward toward rear]. Provide front[and rear] doors with[stainless steel] padlockable vault handles with a three point catch.] Ensure 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 enclosure, including bases, ASTM D1535 light gray No. 61 or No. 49. Paint coating system complies with[IEEE C57.12.28 for galvanized steel][and][IEEE C57.12.29 for stainless steel].

NOTE: Mounting sills should be included for all new construction to provide structural integrity. NEMA PB2 90" height includes these sills.

[Each switchboard enclosure is NEMA type [2] [3R], built with selected smooth sheet steel panels of not less than 1.9 mm No. 14 gage. Exposed panels on the front and ends have bent angle or channel edges with all corner seams welded and ground smooth. 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 ventilating openings as required and preferably be of the grille type. Provide all ventilating openings with corrosion-resistant insect-proof 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.

]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 bus bars are[copper with silver-plated contact surfaces][or][aluminum with tin-plated contact surfaces]. Plating is a minimum of 0.005 mm 0.0002 inch 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 minimum 6.35 mm by 50.8 mm one-quarter by 2-inch copper ground bus 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 per 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.

[All buses are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] are tin or silver-plated [throughout]. 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. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. Insulate buses for not less than 600 volts. Braze, pressure-weld or bolt splices and tap connections. Bolt 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. Mount near the bottom of enclosure a copper [or aluminum] ground bus, rated not less than 300 amps, extending the entire length of the assembled structure. Provide a full clamp-type 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 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: Switchboard should be placed 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, 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

IEEE C37.13. [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. Breaker frame size is[as indicated][[_____] amperes].[Equip electrically operated breakers with 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 an 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. Breaker frame size is [[_____] amperes][as indicated].[Equip electrically operated breaker with 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

Conform breaker to UL 489. Ensure breaker is 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 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

Fusible Switches: Quick-make, quick-break, hinged-door type.[Ensure switches serving as motor disconnects are horsepower rated.] Fuses are current-limiting cartridge type 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].

Fuseholders: UL 4248-12.

][2.2.2.5 Integral Combination Breaker and Current-Limiting Fuses

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 coordination of overcurrent devices of the circuit breaker and current-limiting fuses is such that on overloads or fault currents of relatively low value, the overcurrent device of the breaker are operated to clear the fault. For high magnitude short circuits above a predetermined value[crossover point], ensure the current-limiting fuses operate to clear the fault. Housing for the current-limiting fuses are 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 a blown fuse is readily evident by means of a visible indicator. Removal of fuse housing causes the breaker contacts to open, and it is not possible to close the breaker contacts with the fuse housing removed. Ensure it is not possible to insert the fuse housing with a blown fuse or with one fuse missing. Ensure 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. The main, auxiliary, and control disconnecting contacts are silver-plated, multifinger, positive pressure, self-aligning type. 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 breaker is tripped before racking into or out of position.
- b. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. 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 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 type 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 only applies 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 have long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.
-][b. Main breakers have[short delay pick-up and time settings][and][, instantaneous settings][and][ground fault settings][as indicated].

-][c. Distribution breakers have[short delay pick-up 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, vars, VA, kWh, kvarh, and kVAh.
-][f. [Main]Breakers have a digital display for phase voltage, and percent 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 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 with a minimum of 50.8 mm square 2-inches square, and 250-degree scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

[2.2.6.1 Ac Ammeters

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

]][2.2.6.2 Ac Voltmeters

Self-contained.

]][2.2.6.3 Instrument Control Switches

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

]][2.2.7 Watthour and Digital Meters

NOTE: When Section 23 09 23.13 20 BACnet DIRECT DIGITAL CONTROL SYSTEM FOR HVAC or Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS 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.

Conform to IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in sealed cases with a simultaneous three line, twelve value LED display. Ensure meters have 16 mm) 0.56-inch, minimum, LEDs.[Watthour meter have 16 mm 0.56-inch, minimum, LEDs.] The meters accept[input from standard 5A secondary instrument transformers][and][direct voltage monitoring range to [300][600] volts, phase to phase]. Programming is via a front panel display and a communication interface with a computer. Password secured programming is stored in non-volatile EEPROM memory. Digital communications are Modbus [ASCII][RTU] protocol via a [RS232C][RS485] serial port[and an independently addressable [RS232C][RS485] serial port]. Ensure the meter calculates and stores average max/min demand values for all readings based on a user selectable sliding window averaging period. Ensure the meter has programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.[Provide a meter with Total Harmonic Distortion (THD) measurement to the thirty-first order.][Historical trend logging capability includes ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Have the unit also store and time stamp up to 100 programmable triggered conditions.][Event waveform recording is triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.]

- [a. Multi-Function Meter: Meter simultaneously displays a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, 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, over percent THD. Ensure the meter has a Form C KYZ pulse output relay.
-][b. Power Meter: Meter simultaneously displays Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.
-][c. Volt Meter: 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, over percent THD.

-][d. Ammeter: Meter simultaneously displays phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.
-][e. Digital Watthour Meter: Meter has a single selectable display for watts, total kilowatt hours (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, semi-flush mounted, as indicated. Meter is either programmed at the factory or programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

- a. Design: Provide meter designed for use on a 3-phase, 4-wire, [208Y/120][480Y/277] volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS)[as specified in[Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]].
- b. Coordination: Provide 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: 5 digit electronic programmable type.
- 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.

]][2.2.7.3 Electro-Mechanical Watthour Meters

NOTE: On standard projects, use of the electronic meter versus the optional electromechanical meter is recommended due to decreasing availability of electromechanical meters.

NEMA/ANSI C12.10. Kilowatt-hour meters are[two][three][four]-stator, transformer rated, polyphase, 60 hertz,[surface][semiflush] mounted,[drawout][semidrawout] switchboard meters[120 volt for use on a four-wire wye, three phase, 208Y/120 volt system][240 volt for use on a four-wire wye, three-phase 480Y/277 volt system]. Provide meter with a five-dial

pointer type register.[Ensure the kilowatt-hour meter has a[sweep-hand][cumulative] type kilowatt demand register with [15][30][60]-minute interval conforming to NEMA C12.4.] Provide correct multiplier on face of meter.

]2.2.8 Current Transformers

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

Select an ANSI Metering Accuracy Class in accordance with the following table:

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

IEEE C57.13. Ensure 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 the transformer and section are suitable for the installation.[Test transformers greater than 10 kVA in accordance with UL 891.] Ensure 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 fuses as recommended by the meter manufacturer.

]2.2.11 Heaters

Provide 120-volt heaters in each [switchboard][switchgear] section. Provide heaters of sufficient capacity to control moisture condensation in the section, are 250 watts minimum, and controlled by a thermostat[and humidistat] located in the section. Provide an industrial type, 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 than switchboard voltage, provide transformer rated to carry 125 percent of heater full load rating. Ensure transformer has 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 switchboard assemblies while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source. Provide temporary, reliable external power source if commercial power at rated voltage is not available on site.]

]2.2.12 Terminal Boards

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

2.2.13 Wire Marking

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

2.2.14 Manufacturer's Nameplate

Ensure each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be 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 note on the drawings to
indicate where red labels are required.**

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 each nameplate inscription identifies the function and, when applicable, the position. Construct nameplates of melamine plastic, 3 mm 0.125 inch thick, white with

[black][_____] center core.[Provide red laminated plastic label with white center core where indicated.] Nameplate surface has a matte finish with square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 25.4 by 63.5 mm 1 by 2.5-inches. Provide lettering with a minimum of 6.35 mm 0.25-inch high normal block style.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Equipment Test Schedule

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

a. Test Instrument Calibration Requirements

- (1) The manufacturer has a calibration program which assures 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) 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) Calibrating standard is of higher accuracy than that of the instrument tested.
- (6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
 - (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
 - (b) Identify the third party/laboratory calibrated instrument to verify that 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 C37.20.1 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 which 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 C37.20.1 and UL 1558]. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

- 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 which are not adjustable or for which coordination is not possible (standard molded case circuit breakers); projects involving simple extension of 600 volt level service to a building or facility from an existing transformer (750 kVA or less); or projects involving simple extension of 600 volt level service to a building or facility from a new transformer (750 kVA or less).

Provide a power system study as specified in Section 26 28 01.00 10
COORDINATED POWER SYSTEM PROTECTION.

]PART 3 EXECUTION

3.1 INSTALLATION

Ensure 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.

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 equipment end of ground conductors.

3.1.1.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG 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 to obtain the specified ground resistance, the provision of the contract covering "Changes" apply.

3.1.1.3 Connections

Make 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 entitled, "Grounding Connections."

3.1.1.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.1.2 Installation of Equipment and Assemblies

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

3.1.2.1 [Switchboard

ANSI/NEMA PB 2.1.

]3.1.2.2 [Switchgear

IEEE C37.20.1.

]3.1.2.3 [Meters and Instrument Transformers

ANSI C12.1.

]3.1.2.4 Field Applied Painting

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

3.1.2.5 Galvanizing Repair

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

3.1.2.6 Field Fabricated Nameplate Mounting

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

3.1.3 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 [switchboard][switchgear] on concrete slab. Unless otherwise indicated, the slab is at least 200 mm 8-inches thick, reinforced with a 150 by 150 mm 6 by 6-inch No. 6 mesh placed uniformly 100 mm 4-inches from the top of the slab. Place slab on a 150 mm 6-inch thick, well-compacted gravel base. The top of the concrete slab is approximately 100 mm 4-inches above the finished grade. Edges above grade have 15 mm 1/2-inch chamfer. Ensure the slab is of adequate size to project at least 200 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 slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3-inches above slab surface. Concrete work is as specified in Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 00.00 10 CAST-IN-PLACE CONCRETE][03 35 00.00 10 CONCRETE FINISHING][03 39 00.00 10 CONCRETE CURING].

3.1.3.2 Interior Location

Mount [switchboard][switchgear] on concrete slab. Unless otherwise indicated, the slab is at least 100 mm 4-inches thick. The top of the concrete slab is approximately 100 mm 4-inches above finished floor. Edges above floor have 15 mm 1/2-inch chamfer. The slab is of adequate size 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 slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm 3-inches above slab surface. Concrete work is specified in Section[03 30 00 CAST-IN-PLACE CONCRETE][03 30 00.00 10 CAST-IN-PLACE CONCRETE][03 35 00.00 10 CONCRETE FINISHING][03 39 00.00 10 CONCRETE CURING].

3.2 FIELD QUALITY CONTROL

Submit request for settings of breakers to the Contracting Officer after approval of [switchboard][switchgear] and at least 30 days in advance of 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 low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing 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 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 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 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 calibrated torque-wrench method, or performing 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 Breaker(s) 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 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 ensure 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 and/or cable connections by calibrated torque-wrench method, or performing 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 anti-pump function.

]3.2.1.5 Current Transformers

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 calibrated torque-wrench method, or performing 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 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) IEEE 81. Perform ground-impedance measurements utilizing 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 manufacturer's instructions to test each ground or group of grounds. Ensure 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 (i.e., 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. As an exception to requirements stated elsewhere in the contract, give the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --