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USACE / NAVFAC / AFCEC / NASA **UFGS-33 75 00.00 40 (November 2014)**

Preparing Activity: NASA **Superseding**
UFGS-33 75 00.00 40 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2021
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DIVISION 33 - UTILITIES

SECTION 33 75 00.00 40

SWITCHGEAR AND PROTECTION DEVICES

11/14

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SECTION 33 75 00.00 40

SWITCHGEAR AND PROTECTION DEVICES
11/14

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NOTE: This guide specification covers the requirements for switchgear and switchboards of special design or configuration. For primary-unit substations, use Section 26 11 16 SECONDARY UNIT SUBSTATIONS; for motor control centers, use Section 26 24 19.00 40 MOTOR CONTROL CENTERS; for power panelboards, use Section 26 24 16.00 40 PANELBOARDS. Show switchgear/switchboard elevation, dimensions, devices, instruments, and installation on drawings.

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

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

1.1 REFERENCES

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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 are automatically deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2021) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 4	(2013) Standard Techniques for High Voltage Testing
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
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 C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.90	(2015; Corr 2017) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

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

UNDERWRITERS LABORATORIES (UL)

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

1.2 SUBMITTALS

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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.

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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-01 Preconstruction Submittals

Switchgear Assemblies[; G[, [____]]]

SD-02 Shop Drawings

Switchgear Assemblies[; G[, [____]]]

Buses[; G[, [____]]]

Switchgear Components[; G[, [____]]]

Automatic/Manual Transfer Switch[; G[, [____]]]

Space Heaters[; G[, [_____]]]

Enclosures[; G[, [_____]]]

Weatherproof Enclosures[; G[, [_____]]]

Installation Drawings[; G[, [_____]]]

SD-03 Product Data

Equipment and Performance Data[; G[, [_____]]]

Equipment Foundation Data[; G[, [_____]]]

Switchgear Assemblies[; G[, [_____]]]

Enclosures[; G[, [_____]]]

Buses[; G[, [_____]]]

Switchgear Components[; G[, [_____]]]

Weatherproof Enclosures[; G[, [_____]]]

Automatic/Manual Transfer Switch[; G[, [_____]]]

Space Heaters[; G[, [_____]]]

SD-06 Test Reports

Electrical Acceptance Tests[; G[, [_____]]]

High-Voltage Tests[; G[, [_____]]]

Current Test[; G[, [_____]]]

Insulation-Resistance Test[; G[, [_____]]]

Weatherproof Test[; G[, [_____]]]

Electrical Current and Voltage Tests[; G[, [_____]]]

Ratio and Polarity Tests[; G[, [_____]]]

High-Voltage (Hi-Pot) Withstand Test[; G[, [_____]]]

Final Test Data[; G[, [_____]]]

SD-07 Certificates

Certificates[; G[, [_____]]]

SD-08 Manufacturer's Instructions

Switchgear Assemblies[; G[, [_____]]]

SD-10 Operation and Maintenance Data

Switchgear Assemblies[; G[, [_____]]]

Transfer Switches[; G[, [_____]]]

Space Heaters[; G[, [_____]]]

1.3 MAINTENANCE MATERIAL SUBMITTALS

Submit manufacturer's instructions for the switchgear assemblies including special provisions required to install equipment components and system packages. Provide special notices that detail impedances, hazards, safety precautions, and installation instructions.

1.4 QUALITY CONTROL

1.4.1 Manufacturer Qualifications

Provide material and equipment under this specification that is the standard catalog product of a manufacturer regularly engaged in the manufacture of switchgear assemblies and their component parts and equipment. Provide equipment that is of the latest standard design for [indoor] [outdoor] service and that has been in repetitive manufacture for at least [50] [_____] units.

1.4.2 Engineer Qualifications

Perform electrical power system's circuit loading requirements and analyses by a professional electrical engineer registered with the National Society of Professional Engineers (NSPE). Select a professional engineer who has conducted electrical coordination studies and tests for not less than five projects of comparable size and complexity. Perform work by or under the direct supervision of the registered professional electrical engineer.

Submit certificates to verify the qualifications of the Registered Professional Electrical Engineer.

1.4.2.1 Engineering Services

Select an electrical engineer holding a valid state license as a Professional Engineer in the jurisdiction where the project is being constructed, and who specializes in relays and coordinating systems associated with electric-power apparatus for the manufacturer of the equipment, to coordinate all circuit-interrupting devices before the substation is energized. Duties and responsibilities of the engineer include the following work.

a. Preliminary Survey and System Coordination Study

Review necessary short-circuit calculations to determine the minimum and maximum values of short-circuit current for faults anywhere in the system. Review values of fault current to be expected at each protective device shown on the one-line diagrams.

Prepare one-line diagrams that indicate by means of single lines and simplified symbols the course and component devices of an electric circuit or system of circuits and their electrical characteristics.

Inspect equipment and determine the intended function of each

circuit-interrupting device and the manner in which it is connected to provide a properly coordinated electrical power system under normal load and fault conditions.

Check and compare wiring diagrams furnished by the manufacturer with actual connections of the equipment to verify that each device is properly connected to perform its intended function.

b. Time/Current Curves and Settings

Plot time/current curves on a single sheet of graph paper or electronic format for those devices that are to operate selectively in series with each other using a common current scale, with current ratings at the lowest-voltage level. Plot curves progressively as each circuit is studied, starting with the device farthest from the source. Make each curve on the graph include tolerance band and show degree of coordination with each successive device. Coordinate adjustable and nonadjustable protective devices to operate on the minimum current that permits distinguishing between fault and load current in a minimum amount of time.

Select time and current settings for the adjustable devices that operate in sequence with the nonadjustable devices to isolate a fault with a minimum of disturbance to the unfaulted portion of the system.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit switchgear assemblies that conform to IEEE C37.20.1A.

Submit equipment and performance data for electrical equipment consisting of the following:

a. One-line diagram of electrical equipment and system.

b. Short-circuit calculations and a table of short-circuit fault currents at critical points in the electrical system.

c. Spare Parts Data

d. Time/current coordination curves on 270 by 380 millimeter 10 1/2 by 15 inch translucent tracing paper for each relay device.

e. Table of recommended relay settings.

Submit equipment foundation data for switchgear assemblies that includes plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

2.1.1 Design Requirements

Submit connection diagrams indicating the relations and connections of the following items: switchgear assemblies, buses, switchgear components, automatic/manual transfer switch, and space heaters. Show the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings consisting of fabrication and assembly details to be performed in the factory for the following items: switchgear assemblies, buses, switchgear components, automatic/manual transfer switch, enclosures, and space heaters.

2.2 FABRICATION

2.2.1 Switchgear and Auxiliary Compartments

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NOTE: Ability to remove access covers is required for maintenance activities. In addition, access may be required to inspect this device while circuits are energized (for example, using infrared imaging). Minimum distances to energized circuits is specified in OSHA Standards Part 1910.333 (Electrical - Safety-Related work practices). OSHA Standards are available on the internet.
****

Stationary mount switchgear assemblies and auxiliary equipment in self-supporting, self-contained, sheet metal enclosures with front-hinged doors and hinged rear covers. Join sheet metal compartments together to form a continuous structure. Provide sheet metal barriers, enclosures, and external covers and doors that are constructed from cold-rolled carbon-steel sheets of commercial quality not less than [1.9] [_____] millimeter [14] [_____]-gage, with stretcher-level flatness in accordance with ASTM A1008/A1008M.

Provide unit sheet metal that encloses one or more vertically mounted power circuit breakers or auxiliary equipment in individual sheet metal compartments and a full height rear compartment. Provide housing that is approximately 2300 millimeter 90-inches high with individual ventilated [front] [rear]-hinged panels and bolted top and rear covers. Provide rear compartment that contains the main bus, main bus-tap connections, cable connections, and instrument transformers.

2.2.2 Compartment Details

Completely wire compartments with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Provide terminal blocks that are readily accessible for the external connections of metal-clad switchgear.

Run low-voltage wiring for controls and accessories to terminal blocks having numbered points, as indicated, to identify circuits. Run low-voltage wiring in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Identify wiring connections.

Identify each compartment of the switchgear assembly by an identification plate engraved with circuit and function designations.

Provide removable elements of the same type and rating in the switchgear assembly that are physically and electrically interchangeable in corresponding compartments. Provide front-hinged panel that is suitable for mounting instruments, relays, control switches, and indicating lamps.

Provide barriers between a sectionalized bus with bus sectionalizing

breakers in a compartment that are sheet steel not less than [3.1] [_____] millimeter [11] [_____] gage. Provide other covers, barriers, panels, and doors that are not less than [1.9] [_____] millimeter [14] [_____] gage.

Reinforce each compartment with structural members and weld together. Ground welds to a smooth flat surface before painting.

2.2.3 Buses

Completely bus switchgear assemblies utilizing electrical grade, high conductivity, solid copper bus bar having a rectangular cross section. Uniformly position and phase sequence, riser and bus tap connections in accordance with IEEE C37.20.1A. Support and brace buses to withstand both electrically and mechanically the short circuit current ratings.

Silverplate termination and connection points by an electroplating process for all bus bar used in the switchgear. Silver coating methods that do not use the flow of electrical current as part of the process are not acceptable. After plating, do not sand or otherwise abrade the contact surface, but clean it with a soft cloth immediately prior to final assembly.

Make all bus bar connections using silicon bronze bolts with wide flat silicon bronze washers under the bolt head and nut. Tighten and check these connections by use of a calibrated torque wrench. Other connection designs are allowed with the written agreement of the Contracting Officer.

[Provide main bus that is readily accessible for connection of future switchgear assemblies at either end. Provide main and auxiliary control drawout type connections that are silver-to-silver contact, positive pressure, self-aligning, with enclosure-to-enclosure stationary mechanism when breaker is in drawout position.

] Provide voltage rating and insulation level of switchgear assemblies as specified and that conform to IEEE C37.20.1A.

Provide temperature limits for buses and bus-tap connections in switchgear assemblies that are in accordance with IEEE C37.20.1A.

Provide a continuous rigid copper ground bus that extends throughout the entire assembly and that grounds the stationary structure and equipment. Provide ground bus that is capable of carrying the rated short circuit current of the protective devices in the switchgear assembly for a minimum period of one second.

Completely wire compartments with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Provide terminal blocks that are readily accessible for the external connections of metal-clad switchgear.

Run low-voltage wiring for controls and accessories to terminal blocks having numbered points, as indicated, to identify circuits. Run low-voltage wiring in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Identify wiring connections.

Identify each compartment of the switchgear assembly by an identification plate engraved with circuit and function designations.

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NOTE: Delete the following paragraphs when the switchgear units are not bus connected.

****

Provide metal-enclosed bus of non-segregated group phase construction that includes rigid insulated conductors and supports in a grounded metal enclosure with associated ventilation and space-heater enclosures, condensation barriers, expansion and connection joints, and fittings in accordance with IEEE C37.20.1A.

Completely bus enclosures with an insulated solid rigid copper bus bar of rectangular cross section. Uniformly position and phase sequence bar and connections within the enclosure for adaptation to metal-clad switchgear assemblies and power transformers, in accordance with IEEE C37.20.1A.

Support and brace bus bar to withstand short-circuit stresses with momentary current ratings, in accordance with IEEE C37.20.1A. Silverplate and bolt together contact surfaces of all bus connections to ensure maximum conductivity. Provide voltage and current ratings that conform to IEEE C37.20.1A.

Provide insulating supports that consist of track-resistant, flame-retardant IEEE Class 130 electrical insulating materials. Provide voltage rating and insulation level that conform to IEEE C37.20.1A.

Provide sheet metal weatherproof enclosures that are constructed from carbon steel sheets of commercial quality, not less than [1.9] [_____] millimeter [14] [_____] gage. Reinforce each section with structural members and bolt together. Structurally support complete assembly as indicated.

2.2.4 Automatic/Manual Transfer Switch

Make provision for the automatic transfer of load on loss of voltage, low voltage, single phasing, reverse phase rotation of either source, and the automatic transfer of load upon restoration of normal service without a service interruption. Under normal operation, close both main secondary breakers with the main bus tie breaker open and the automatic/manual transfer control switch in the automatic position, and energize and load each source of supply.

Electrically operate main and bus tie breakers with remote pushbutton controls electrically interlocked so that only two of the three breakers close by operation of the respective breaker-closing mechanisms when the automatic/manual transfer control switch is in the manual position.

Ensure main secondary breaker compartments include undervoltage and phase-sequence relays with adjustable time-delay between 30 and 200 cycles.

Provide auxiliary relays that automatically open the proper main secondary breaker and close the main bus tie breaker under fault conditions. Include provisions for the automatic reclosing of the main secondary breakers before opening the main bus tie breaker when normal service is restored.

Provide lockout relays that prevent automatic transfer of load from undervoltage caused by overload or transient conditions. Provide lockout relay controls that are connected into the closing circuit of the main tie breaker to prevent operation under lockout conditions and that are the

hand-reset type.

Provide main bus tie breaker compartment that includes an automatic/manual transfer switch which disconnects the automatic transfer features when in the manual position. Provide main secondary and bus tie breakers that are manually inoperable when the automatic/manual transfer control switch is in the automatic position.

Provide a bypass switch to permit manual momentary paralleling of the two sources of supply in restoring normal service without interruption.

Provide main secondary and bus tie breakers that are manually operable when the automatic/manual transfer control switch is in the manual position.

Provide a contactor for the automatic transfer of control power. Provide control power transformers that capable of furnishing power through the selective contactor for the bus tie breaker, feeder breakers, compartment heaters, interior lighting, utility outlets, battery chargers, and other miscellaneous equipment.

Supply secondary switchgear assembly or assemblies from two separate sources, with each source normally carrying load as indicated. Under normal operation, close both main secondary breakers with the main bus tie breaker open. Do not operate two sources of supply in parallel.

2.2.5 Switchgear Assemblies

Provide general arrangement of the number of compartments and each compartment's components as shown.

[Provide bus sectionalizing switchgear compartments that include a metal-enclosed low-voltage power circuit breaker.

][Provide secondary feeder switchgear compartments that include the following equipment:

[a. Metal-enclosed low-voltage power circuit breaker

][b. Provisions for terminating cables of the metal-enclosed bus

]][Provide auxiliary station power compartments that include the following:

[a. Control-power transformer and primary fuses

][b. Circuit overload protection

][c. Potential transformers for relaying purposes

][d. Lamp ground detectors

][e. Batteries and battery charger

][f. Circuit breaker control transformer

]][Provide auxiliary metering compartments that include the following:

[a. Current transformers

][b. Ammeters and ammeter switches

][c. Potential transformers

][d. Voltmeters and voltmeter switches

][e. Watt-hour meters

][f. Reverse current directional relays

][g. Lamp ground detectors

][h. Cooling fans

]][Provide auxiliary bus sectionalizing compartments that include a contactor for automatic transfer of control power and auxiliary devices.

][Provide switchgear compartments for future use that are fully equipped to receive the removable element with complete bus connections, disconnecting devices, rails, and cell interlocks.

][Provide filler compartments incidental to the switchgear assembly that are empty compartments with hinged cover plates.

][Provide main and feeder power circuit breakers that are suitable for fully rated [nonselective] [selective] trip systems in accordance with IEEE C37.121.

]2.2.6 Weatherproof Construction

Provide switchgear assemblies for outdoor applications that are weatherproof NEMA Type 3R enclosures, with ventilated [front] [and rear]-hinged doors, base, and roof sections. Provide flanged access doors that close against rubber or similar gasketing material. Provide ventilated openings with filtered covers and screened vents for protection against the weather and insects. Equip doors with latch, stops, and door-locking mechanism.

Provide roof section that is unit construction with removable sloping cover and overhanging roof drip edge. Provide base section that is unit construction and that supports metal-enclosed switchgear [150] [_____] millimeter [six] [_____]-inches above the concrete foundation.

[Provide switchgear enclosures that include a removable steel floor plate which is drilled for conduit and cable during installation. Undercoat floor and roof of the switchgear with a heavy rubberized protective sealing material at least [0.79] [_____] millimeter [1/32] [_____]-inch thick.

][Equip each enclosure subject to an outside or humid environment with thermostatically controlled electric space heaters and cooling fans to minimize condensation. Make provisions for terminating incoming and outgoing underground cables.

]2.2.7 Painting

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NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Section

09 96 00 HIGH-PERFORMANCE COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation breaks down most standard coatings, causing a phenomena known as chalking, which is the first stage of the corrosion process. For additional information contact The Coatings Industry Alliance, specific suppliers such as Keeler and Long and PPG, and NACE International (NACE).
****

After fabrication, prepare and paint exposed ferrous-metal surfaces of switchgear assemblies and component equipment. Provide standard finish by the manufacturer on assemblies and component equipment when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3 SWITCHGEAR COMPONENTS

2.3.1 Air Interrupter Switches

Provide the manually group-operated three-pole, gang-operated, stationary type air interrupter switches in accordance with IEEE C37.121 and IEEE C37.20.1A, that carry the rated current continuously.

Provide stored energy type quick-make/quick-break operating mechanism with positive action for fault closing and load-interrupting capability. Provide a handle speed that is independent of operation.

[Provide the stored energy type operator, designed for easy inspection with a basic impulse level (BIL) of [95 at 14.4 kilovolts] [110 at 35 kilovolts]. Mechanically interlock access door with a switch mechanism. Provide [2.7] [_____] millimeter [12] [_____]-gage minimum sheet steel switch enclosure. Provide switch gear to switch connections that prevent ground transmission to switch.

][Make provision for terminating underground cables and for bus connections to the primary of the transformer transition box. Use flexible connections between primary potheads and the interrupter switch with adequate bracing provided for short circuit stresses.

] Provide switch that has provisions for padlocking in the open and closed positions. Clearly and permanently mark open and closed switch positions on the outside of the enclosure. Provide a mechanical indicator that shows the switch position.

Provide switch with provision to add electrical operation with auxiliary contacts, and is a [two-position, single-throw] [duplex dual feeders] [selector] type.

[Equip interrupter switchgear with three current-limiting [CLE type] [RBA boric acid] power fuses capable of interrupting the available short circuit current with the switch carrying full load rated current. Provide a mechanical interlock to prevent access to the power fuses when the interrupter switch is closed.

]2.3.2 Power Circuit Breakers

Provide air circuit breakers of the [manually] [electrically] operated type as indicated, conforming to Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.3 Molded-Case Circuit Breakers

Provide molded-case circuit breakers that conform to Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.4 Instruments and Instrument Transformers

Provide indicating instruments, protective relays, current and potential transformers, instrument transfer switches, and control-power transformers that conform to the applicable requirements of Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.5 Control-Power Circuit Overcurrent Protection

Provide branch-circuit breakers that provide circuit overload protection to compartment heater, lights, convenience outlets, transformer fans, and other devices.

2.3.6 Automatic/Manual Transfer Switch

Provide the rotary snap-action type automatic/manual transfer switch with silver-plated contacts. Provide a manually operated two-position transfer switch device designed to interrupt the automatic transfer and close-back features of the system when the transfer switch is in the manual position. Ensure switch permits the transfer of all load to a particular switchgear assembly without a service interruption when the transfer switch is in the automatic position.

2.3.7 Control-Power Circuit Contactor

Provide a contactor for automatic transfer of control-power that is designed for 120/240-volt, single-phase, 60-Hz service with current rating. Provide contactor that is the open type, two-pole, double-throw with solid neutral connections and that automatically transfers its load circuits to the alternate power supply upon loss of power in the normal supply. Provide a device that is electrically operated and mechanically held and that obtains its operating current from the source to which the load is transferred. Provide contactors for automatic transfer of control power that is suitable for installation in metal-clad switchgear.

2.3.8 Service and Maintenance Devices

Include the following service and maintenance devices as a part of the substations:

a. A manual handle for operating the air and power circuit breaker isolating mechanism

b. Removable manual maintenance closing devices for air and power circuit breakers

c. Transfer trucks for air and power circuit breakers

d. Facilities for operating air and power circuit breakers in the test or removed position

e. Facilities for withdrawing air and power circuit breakers for inspection or maintenance

f. Test plugs and cable for meters and relays

2.3.9 Protective Relays and Devices

Provide protective relays and devices that comply with Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.10 Space Heaters

****

NOTE: Include the following paragraphs for outdoor switchgear assemblies and indoor assemblies which are in humid environments. Provide space heaters to prevent moisture build-up in ventilated compartments.

Wattage supplied by heaters is one-fourth of heater nameplate rating when 240-volt heaters are operated at 120 volts.

****

Equip each section of the switchgear assembly with externally energized space heaters providing approximately 40 watts per square meter 4 watts per square foot of outer surface area. Provide heaters that have a power density that does not exceed 4 watts per 650 square millimeter per square inch of heater element surface. Provide heaters rated at 240 volts for connection to 120 volts. Locate heaters at the lowest portion of each space to be heated. Cover terminals. Use thermostats to regulate the temperature.

Provide heaters that are installed and operable at the time of shipment so that the heaters can be operated immediately upon arrival at the site, during storage, or before installation. Provide connection locations that are marked prominently on drawings and shipping covers and that have temporary leads for storage operation. Make leads easily accessible without having to remove shipping protection.

2.3.11 External Voltage Source

Group together all externally powered wiring to the switch as much as possible and connected to a terminal block which is marked with a laminated plastic nameplate having 5 millimeter 3/16-inch high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

Provide externally powered wiring that includes 120-volt unit space heaters.

2.4 FACTORY TESTING

Make factory tests on transformers and switchgear assemblies in accordance with the applicable provisions of the referenced standards.

Perform tests on transformers that include resistance measurements of windings, ratio tests, polarity and phase-rotation tests, no-load loss at rated voltage, excitation current at rated voltage, impedance voltage and load-loss at rated current, insulation power factor tests, and dielectric tests. Conduct tests in accordance with IEEE C57.12.90.

Perform tests on switchgear assemblies that include mechanical operational tests, electrical operation and control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Conduct tests in accordance with IEEE 4.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation drawings for the switchgear assemblies. Provide drawings that include complete details of equipment layout and design.

Make installation conform to IEEE C2 and NFPA 70.

Electrically and mechanically connect complete assembly together at the site from coordinated subassemblies shipped in complete sections from the manufacturer. Provide installation that is carefully aligned, leveled, and secured to the foundation and that conforms to the manufacturer's recommendations.

Install noncurrent carrying parts and enclosures of the switchgear; bonded together and grounded to the ground grid with a maximum resistance to ground of 20 ohms. Exothermically weld inaccessible ground connections in accordance with UL 467. The minimum size of ground conductor is 11.7 millimeter diameter 4/0 AWG.

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NOTE: The following applies to high-voltage switchgear only.
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Provide switchgear with an earth ground resistance pad as shown on the drawings. Provide a switchgear resistance to ground that does not exceed the following values:

5,000 kVA and above	3 ohms
5,000 kVA and below	5 ohms

For switchgear assemblies separated for shipping, carefully join assemblies to present a neat appearance. Tighten main and ground bus joints to manufacturer's recommended torque values. Handle assemblies with lifting devices.

3.2 FIELD TESTING

Subject main bus of switchgear assemblies to insulation resistance and high-voltage, 60-hertz withstand tests after installation is completed and

ready for operation. Perform electrical current and voltage tests in accordance with referenced standards in this section.

Provide test equipment, labor, and technical assistance to perform the electrical acceptance tests as herein specified.

Disconnect incoming section main bus from the power supply and primary feeder cables, and ground the switchgear enclosure before the insulation and high-voltage tests are conducted.

Disconnect outgoing section main bus from the secondary feeder cables and from the power supply and primary feeder cables. Ground the switchgear enclosure before conducting insulation and high-voltage tests.

Conduct an insulation-resistance test on the main bus of the incoming section with a [5,000] [2,500]-volt insulation-resistance test set.

Conduct an insulation-resistance test on the main bus of the outgoing section with a [1,000] [2,500] [500]-volt insulation-resistance test set.

Apply test for not less than five minutes and until three equal consecutive readings, one minute apart, are obtained. Record readings every 30 seconds during the first two minutes and every minute thereafter. Minimum acceptable resistance reading is 100 megohms.

Upon satisfactory completion of the insulation-resistance test, subject the main bus to a high-voltage (hi-pot) withstand test. Provide test voltage that is equal to [100 percent for 60 Hz] [75 percent for dc] of the values shown in IEEE C37.20.1A for metal-clad switchgear and metal-enclosed low-voltage power-circuit-breaker switchgear. Apply test for one minute.

Upon satisfactory completion of the high-voltage withstand test, give the main bus a second insulation-resistance test as before. Results of the second test are required to be within five percent of the first test and indicate no evidence of permanent injury by the high-potential test.

Subject weatherproof enclosure and switchgear assembly to a weatherproof test conducted at the site in the presence of the Contracting Officer in accordance with IEEE C37.20.1A.

Provide tests on switchgear assemblies that include electrical and mechanical operational tests, control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Conduct tests in accordance with IEEE 4.

Final acceptance depends upon the satisfactory performance of the equipment under test. Provide final test data to the Contracting Officer. Provide data with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Data - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 SYSTEM STARTUP

3.3.1 Relay Settings And Tests

Properly coordinate circuit-interrupting devices before the switchgear assemblies are energized. Thoroughly inspect and adjust relays at the

site in the presence of and at the discretion of the Contracting Officer.

3.3.2 Preliminary Inspection

Conduct preliminary inspection of electrical equipment. Make relay settings and tests only after the preliminary survey and system coordination survey have been completed. Provide preliminary inspection, relay settings, and tests as follows:

a. Inspect equipment for damage or maladjustment caused by shipment or installation. Remove wedges, ties, blocks, and other packing material installed by manufacturer to prevent damage in shipment.

b. Verify protective relays, auxiliary relays, trip coils, trip circuit seal-in and target coils, fuses, and instrument transformers to be of the proper type and range.

c. Perform electrical continuity tests on current, potential, and control circuits.

d. Perform Ratio and polarity tests on current and potential transformers.

e. Perform insulation tests on relays, wiring, instrument-transformer secondary windings, and instruments.

Remove each adjustable relay from its case and calibrate separately as an instrument, using a variable alternating-current source and an accurate timing device. Verify with this procedure that the relay has not been damaged in shipment and that it performs in accordance with previously prepared time-current coordination curves at specified current tap and time dial settings.

With the relay disconnected and the main current transformer effectively open, apply a current test to the remainder of the secondary circuit to detect any open or short-circuit connections.

Reinstall and connect relays into their current-transformer secondary and control circuits.

Report any defects in electrical equipment, protective devices, wiring, or other conditions that prevent complete coordination and the successful operation of equipment to the Contracting Officer before proceeding with the work.

After the installation has been thoroughly tested and certified to be in satisfactory condition, with relays calibrated and adjusted to the proper current tap and time dial setting, request permission to energize the equipment at system voltage for final testing.

3.3.3 Energizing Switchgear Assemblies

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NOTE: When required by the project, replace the following paragraphs with the statement "Switchgear assemblies will be energized by Government personnel."
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Do not energize switchgear assembly until it is completely installed,

tested, approved by the Contracting Officer, and ready for operation. Conduct site testing and obtain approval from the Contracting Officer.

Using ammeter, voltmeter, and wattmeter or phase-angle meter, measure and compare the values and polarities of voltage and current with those expected in the various relay circuits. Inspect and note positions of directional elements and the voltage relays.

After inspection and satisfactory tests have been completed on all active relay circuits under a no-load condition, give each relay an operational test with diverted load currents or simulated ground faults.

Prepare a report with records of connections, electrical constants, settings, test values, operating performance, and failures or weaknesses found on test.

Perform tests and procedures for testing in accordance with the manufacturer's recommendations, as approved by the Contracting Officer. Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --