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USACE / NAVFAC / AFCESA / NASA **NASA-16445S (December 2005)**

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16445S

SWITCHGEAR ASSEMBLIES

12/05

-- End of Section Table of Contents --

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SECTION 16445S

SWITCHGEAR ASSEMBLIES
12/05

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers switchgear and switchboards of special design or configuration. For primary-unit substations, use Section 16365 PRIMARY UNIT SUBSTATION; for secondary-unit substations, use Section 16366S SECONDARY UNIT SUBSTATION; for motor-control centers, use Section 16345S MOTOR CONTROL; for power panelboards, use Section 16446S PANELBOARDS. Drawings should show switchgear/switchboard elevation, dimensions, devices, instruments, and installation.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.
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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 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.

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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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C37.121	(1989; R 2000) American National Standard for Switchgear-Unit Substation-Requirements

ASTM INTERNATIONAL (ASTM)

ASTM A 1008/A 1008M	(2004b) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2002) National Electrical Safety Code
IEEE C37.20.1	(2002) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C57.12.90	(1999) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE Std 4	(1995) Standard Techniques for High Voltage Testing

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code 2005 Edition

UNDERWRITERS LABORATORIES (UL)

UL 467	(2001) UL Standard for Safety Grounding and Bonding Equipment

1.2 SYSTEM DESCRIPTION

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NOTE: If Section 16003S GENERAL ELECTRICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted, and the following paragraph deleted.

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Section 16003S GENERAL ELECTRICAL PROVISIONS applies to work specified in this section.

Certificates shall be submitted to verify the qualifications of the Registered Professional Electrical Engineer.

Equipment and Performance Data shall be submitted for electrical equipment consisting of the following:

One-line diagram of electrical equipment and system.

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

Spare Parts Data

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

Table of recommended relay settings.

Equipment Foundation Data for switchgear assemblies shall include 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.

1.3 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

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

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

item for Army projects.
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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.] Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Switchgear assemblies shall not be energized until recorded test data have been approved by the Contracting Officer.

SD-02 Shop Drawings

Connection diagrams shall be submitted indicating the relations and connections of the following items by showing 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.

Switchgear Assemblies
Buses
Switchgear Components
Automatic/Manual Transfer Switch
Space Heaters

Fabrication drawings shall be submitted for the following items consisting of fabrication and assembly details to be performed in the factory.

Switchgear Assemblies
Enclosures
Buses
Switchgear Components
Weatherproof Enclosures
Automatic/Manual Transfer Switch
Space Heaters

Installation Drawings shall be submitted for the switchgear assemblies in accordance with the paragraph entitled, "Installation," of this section.

SD-03 Product Data

Equipment and Performance Data shall be submitted for electrical equipment in accordance with paragraph entitled, "System Description," of this section.

Equipment Foundation Data for switchgear assemblies shall be submitted in accordance with paragraph entitled, "System Description," of this section.

Manufacturer's catalog data shall be submitted for the following items:

Switchgear Assemblies

Enclosures
Buses
Switchgear Components
Weatherproof Enclosures
Automatic/Manual Transfer Switch
Space Heaters

SD-06 Test Reports

Test reports shall be submitted for the following tests on switchgear assemblies in accordance with the paragraphs entitled, "Field Testing" and "Relay Settings and Tests," of this section.

Electrical Acceptance Tests
High-Voltage Tests
Current Test
Insulation-Resistance Test
Weatherproof Test
Electrical Current and Voltage Tests
Ratio and Polarity Tests

SD-07 Certificates

Certificates shall be submitted in accordance with paragraph entitled, "System Description," of this section.

SD-08 Manufacturer's Instructions

Manufacturer's instructions shall be submitted for the Switchgear Assemblies including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards, safety precautions, and installation instructions.

SD-10 Operation and Maintenance Data

Operation and maintenance manuals shall be submitted for the following equipment:

Switchgear Assemblies
Transfer Switches
Space Heaters

1.4 FACTORY TESTING

Factory tests on transformers and switchgear assemblies shall be made in accordance with the applicable provisions of the referenced standards.

Tests on transformers shall 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. Tests shall be conducted in accordance with IEEE C57.12.90.

Tests on switchgear assemblies shall include mechanical operational tests, electrical operation and control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Tests shall be conducted in accordance with IEEE Std 4.

1.5 MANUFACTURER QUALIFICATIONS

Material and equipment to be provided under this specification shall be the standard catalog product of a manufacturer regularly engaged in the manufacture of switchgear assemblies and their component parts and equipment. Equipment shall be of the latest standard design for [indoor] [outdoor] service and shall have been in repetitive manufacture for at least [50] [_____] units.

1.6 ENGINEER QUALIFICATIONS

Electrical power system's circuit loading requirements and analyses shall be performed by a professional electrical engineer registered with the National Society of Professional Engineers (NSPE). The professional engineer shall have conducted electrical coordination studies and tests for not less than five projects of comparable size and complexity. Work shall be performed by or under the direct supervision of the registered professional electrical engineer.

1.6.1 Engineering Services

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, shall coordinate all circuit-interrupting devices before the substation is energized. Duties and responsibilities of the engineer shall include the following work.

1.6.1.1 Preliminary Survey and System Coordination Study

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

One-line diagrams shall be prepared 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.

Equipment shall be inspected and the intended function of each circuit-interrupting device and the manner in which it is connected shall be determined to provide a properly coordinated electrical power system under normal load and fault conditions.

Wiring diagrams furnished by the manufacturer shall be checked and compared with actual connections of the equipment to verify that each device is properly connected to perform its intended function.

1.6.1.2 Time/Current Curves and Settings

Time/current curves shall be plotted 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. Curves shall be plotted progressively as each circuit is studied, starting with the device farthest from the source. Each curve on the graph shall include tolerance band and shall show degree of coordination with each successive device. Adjustable and nonadjustable protective devices shall be coordinated to operate on the minimum current

that will permit distinguishing between fault and load current in a minimum amount of time.

Time and current settings shall be selected for the adjustable devices that will 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 EQUIPMENT STANDARDS

Switchgear assemblies shall conform to IEEE C37.20.1.

2.2 CONSTRUCTION

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.
****

Switchgear assemblies and auxiliary equipment shall be stationary mounted in self-supporting, self-contained, sheet metal enclosures with front-hinged doors and hinged rear covers. Sheet metal compartments shall be joined together to form a continuous structure. Sheet metal barriers, enclosures, and external covers and doors shall be 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 A 1008/A 1008M.

Unit sheet metal shall enclose one or more vertically mounted power circuit breakers or auxiliary equipment in individual sheet metal compartments and a full height rear compartment. Housing shall be approximately 2300 millimeter 90 inches high with individual ventilated [front] [rear]-hinged panels and bolted top and rear covers. Rear compartment shall contain the main bus, main bus-tap connections, cable connections, and instrument transformers.

2.2.2 Compartment Details

Compartments shall be completely wired with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Terminal blocks shall be readily accessible for the external connections of metal-clad switchgear.

Low-voltage wiring for controls and accessories shall be run to terminal blocks having numbered points, as indicated, to identify circuits. Low-voltage wiring shall be run in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Wiring connections shall be identified.

Each compartment of the switchgear assembly shall be identified by an

identification plate engraved with circuit and function designations.

Removable elements of the same type and rating in the switchgear assembly shall be physically and electrically interchangeable in corresponding compartments. Front-hinged panel shall be suitable for mounting instruments, relays, control switches, and indicating lamps.

Barriers between a sectionalized bus with bus sectionalizing breakers in a compartment shall be sheet steel not less than [3.1] [_____] millimeter [11] [_____] gage. Other covers, barriers, panels, and doors shall be not less than [1.9] [_____] millimeter [14] [_____] gage.

Each compartment shall be reinforced with structural members and welded together. Welds shall be ground to a smooth flat surface before painting.

2.2.3 Buses

Switchgear assemblies shall be completely bused utilizing electrical grade, high conductivity, solid copper bus bar having a rectangular cross section. Main, riser and bus tap connections shall be uniformly positioned and phase sequenced in accordance with IEEE C37.20.1. Buses shall be supported and braced to withstand both electrically and mechanically the short circuit current ratings.

Termination and connection points of all bus bar used in the switchgear shall be silver plated by an electroplating process. Silver coating methods that do not use the flow of electrical current as part of the process shall not be acceptable. After plating the contact surface shall not be sanded or otherwise abraded, but shall be cleaned with a soft cloth immediately prior to final assembly.

All bus bar connections shall be made using silicon bronze bolts with wide flat silicon bronze washers under the bolt head and nut. These connections shall be tightened and checked by use of a calibrated torque wrench. Other connection designs may be used with the written agreement of the Contracting Officer.

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

Voltage rating and insulation level of switchgear assemblies shall be as specified and shall conform to IEEE C37.20.1.

Temperature limits for buses and bus-tap connections in switchgear assemblies shall be in accordance with IEEE C37.20.1.

A continuous rigid copper ground bus shall extend throughout the entire assembly and shall ground the stationary structure and equipment. Ground bus shall be capable of carrying the rated short circuit current of the protective devices in the switchgear assembly for a minimum period of one second.

Compartments shall be completely wired with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Terminal blocks shall be readily accessible for the external connections of metal-clad switchgear.

Low-voltage wiring for controls and accessories shall be run to terminal blocks having numbered points, as indicated, to identify circuits. Low-voltage wiring shall be run in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Wiring connections shall be identified.

Each compartment of the switchgear assembly shall be identified by an identification plate engraved with circuit and function designations.

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

Metal-enclosed bus shall be of non-segregated group phase construction and shall include 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 C37.20.1.

Enclosures shall be completely bused with an insulated solid rigid copper bus bar of rectangular cross section. Bus bar and connections shall be uniformly positioned and phase sequenced within the enclosure for adaptation to metal-clad switchgear assemblies and power transformers, in accordance with IEEE C37.20.1.

Bus bar shall be supported and braced to withstand short-circuit stresses with momentary current ratings, in accordance with IEEE C37.20.1. Contact surfaces of all bus connections shall be silverplated and bolted together to ensure maximum conductivity. Voltage and current ratings shall conform to IEEE C37.20.1.

Insulating supports shall consist of track-resistant, flame-retardant IEEE Class 130 electrical insulating materials. Voltage rating and insulation level shall conform to IEEE C37.20.1.

Sheet metal weatherproof enclosures shall be constructed from carbon steel sheets of commercial quality, not less than [1.9] [_____] millimeter [14] [_____] gage. Each section shall be reinforced with structural members and bolted together. Complete assembly shall be structurally supported as indicated.

2.2.4 Switchgear Assemblies

General arrangement of the number of compartments and each compartment's components shall be as shown.

[Bus sectionalizing switchgear compartments shall include a metal-enclosed low-voltage power circuit breaker.]

[Secondary feeder switchgear compartments shall include the following equipment:

[Metal-enclosed low-voltage power circuit breaker]

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

[Auxiliary station power compartments shall include the following:

[Control-power transformer and primary fuses]

[Circuit overload protection]

[Potential transformers for relaying purposes]

[Lamp ground detectors]

[Batteries and battery charger]

[Circuit breaker control transformer]]

[Auxiliary metering compartments shall include the following:

[Current transformers]

[Ammeters and ammeter switches]

[Potential transformers]

[Voltmeters and voltmeter switches]

[watt-hour meters]

[Reverse current directional relays]

[Lamp ground detectors]]

[Cooling fans]

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

[Switchgear compartments for future use shall be fully equipped to receive the removable element with complete bus connections, disconnecting devices, rails, and cell interlocks.]

[Filler compartments incidental to the switchgear assembly shall be empty compartments with hinged cover plates.]

[Main and feeder power circuit breakers shall be suitable for fully rated [nonselective] [selective] trip systems in accordance with ANSI C37.121.]

2.2.5 Weatherproof Construction

Switchgear assemblies for outdoor applications shall be weatherproof NEMA Type 3R enclosures, with ventilated [front] [and rear]-hinged doors, base, and roof sections. Access doors shall be flanged and shall close against rubber or similar gasketing material. Ventilated openings shall be provided with filtered covers and screened vents for protection against the weather and insects. Doors shall be equipped with latch, stops, and door-locking mechanism.

Roof section shall be unit construction with removable sloping cover and overhanging roof drip edge. Base section shall be unit construction and shall support metal-enclosed switchgear [150] [_____] millimeter [six] [_____] inches above the concrete foundation.

[Switchgear enclosures shall include a removable steel floor plate which shall be drilled for conduit and cable during installation. Floor and roof of the switchgear shall be undercoated with a heavy rubberized protective sealing material at least [0.79] [_____] millimeter [1/32] [_____] inch thick.]

[Each enclosure subject to an outside or humid environment shall be equipped with thermostatically controlled electric space heaters and cooling fans to minimize condensation. Provisions shall be made for terminating incoming and outgoing underground cables.]

2.3 SWITCHGEAR COMPONENTS

2.3.1 Air Interrupter Switches

Air interrupter switches shall be the manually group-operated three-pole, gang-operated, stationary type in accordance with ANSI C37.121 and IEEE C37.20.1, and shall carry the rated current continuously.

Operating mechanism shall be stored energy type quick-make/quick-break with positive action for fault closing and load-interrupting capability. Handle speed shall be independent of operation.

[Operator shall be the stored energy type, designed for easy inspection with a basic impulse level (BIL) of [95 at 14.4 kilovolts] [110 at 35 kilovolts]. Access door shall be mechanically interlocked with a switch mechanism. Switch enclosure shall be [2.7] [_____] millimeter [12] [_____]-gage minimum sheet steel. Switch gear to switch connections shall prevent ground transmission to switch.]

[Provision shall be made for terminating underground cables and for bus connections to the primary of the transformer transition box. Flexible connections shall be used between primary potheads and the interrupter switch with adequate bracing provided for short circuit stresses.]

Switch shall have provisions for padlocking in the open and closed positions. Open and closed switch positions shall be clearly and permanently marked on the outside of the enclosure. A mechanical indicator shall show the switch position.

Switch shall have provision to add electrical operation with auxiliary contacts, and shall be [two-position, single-throw] [duplex dual feeders] [selector] type.

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

2.3.2 Power Circuit Breakers

Air circuit breakers shall be of the [manually] [electrically] operated type as indicated, conforming to Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.3.3 Molded-Case Circuit Breakers

Molded-case circuit breakers shall conform to Section 16286S OVERCURRENT

PROTECTIVE DEVICES.

2.3.4 Instruments and Instrument Transformers

Indicating instruments, protective relays, current and potential transformers, instrument transfer switches, and control-power transformers shall conform to the applicable requirements of Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.3.5 Control-Power Circuit Overcurrent Protection

Branch-circuit breakers shall provide circuit overload protection to compartment heater, lights, convenience outlets, transformer fans, and other devices.

2.3.6 Automatic/Manual Transfer Switch

Automatic/manual transfer switch shall be the rotary snap-action type with silver-plated contacts. Transfer switch shall be a manually operated two-position device designed to interrupt the automatic transfer and close-back features of the system when the transfer switch is in the manual position. Switch shall permit 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

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

2.3.8 Service and Maintenance Devices

Following service and maintenance devices shall be included as a part of the substations:

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

Removable manual maintenance closing devices for air and power circuit breakers

Transfer trucks for air and power circuit breakers

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

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

Test plugs and cable for meters and relays

2.3.9 Protective Relays and Devices

Protective relays and devices shall comply with Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.4 AUTOMATIC/MANUAL TRANSFER SWITCH

Provision shall be made 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, both main secondary breakers will be closed with the main bus tie breaker open and the automatic/manual transfer control switch in the automatic position, and each source of supply will be energized and loaded.

Main and bus tie breakers shall be electrically operated with remote pushbutton controls electrically interlocked so that only two of the three breakers may be closed by operation of the respective breaker-closing mechanisms when the automatic/manual transfer control switch is in the manual position.

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

Auxiliary relays shall automatically open the proper main secondary breaker and close the main bus tie breaker under fault conditions. Provisions shall be included for the automatic reclosing of the main secondary breakers before opening the main bus tie breaker when normal service is restored.

Lockout relays shall prevent automatic transfer of load from undervoltage caused by overload or transient conditions. Lockout relay controls shall be connected into the closing circuit of the main tie breaker to prevent operation under lockout conditions and shall be the hand-reset type.

Main bus tie breaker compartment shall include an automatic/manual transfer switch which shall disconnect the automatic transfer features when in the manual position. Main secondary and bus tie breakers shall be manually inoperable when the automatic/manual transfer control switch is in the automatic position.

A bypass switch shall be provided to permit manual momentary paralleling of the two sources of supply in restoring normal service without interruption.

Main secondary and bus tie breakers shall be manually operable when the automatic/manual transfer control switch is in the manual position.

A contactor shall be provided for the automatic transfer of control power. Each of the control power transformers shall be 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.

Secondary switchgear assembly or assemblies shall be supplied from two separate sources, with each source normally carrying load as indicated. Under normal operation, both main secondary breakers will be closed with the main bus tie breaker open. Two sources of supply shall not be operated in parallel.

2.5 PAINTING

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NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Section 09960 HIGH-PERFORMANCE COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation will break 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).

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After fabrication, exposed ferrous-metal surfaces of switchgear assemblies and component equipment shall be prepared and painted. Switchgear assemblies and component equipment shall have the standard finish by the manufacturer 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 09960 HIGH-PERFORMANCE COATINGS.

2.6 SPACE HEATERS

****

NOTE: The following paragraphs should be included for outdoor switchgear assemblies and indoor assemblies which are in humid environments. Space heaters will 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.

****

Each section of the switchgear assembly shall be equipped with externally energized space heaters to provide approximately 40 watts per square meter 4 watts per square foot of outer surface area. Heaters shall be such that the power density does not exceed 4 watts per 650 square millimeter per square inch of heater element surface. Heaters shall be rated at 240 volts for connection to 120 volts. Heaters shall be located at the lowest portion of each space to be heated. Terminals shall be covered. Thermostats shall be used to regulate the temperature.

All heaters shall be 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. Connection locations shall be marked prominently on drawings and shipping covers and shall have temporary leads for storage operation. Leads shall be easily accessible without having to remove shipping protection.

2.7 EXTERNAL VOLTAGE SOURCE

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

Externally powered wiring will include 120-volt unit space heaters.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall conform to IEEE C2 and NFPA 70.

Complete assembly shall be electrically and mechanically connected together at the site from coordinated subassemblies shipped in complete sections from the manufacturer. Installation shall be carefully aligned, leveled, and secured to the foundation and shall conform to the manufacturer's recommendations.

Noncurrent carrying parts and enclosures of the switchgear shall be bonded together and grounded to the ground grid with a maximum resistance to ground of 20 ohms. Inaccessible ground connections shall be exothermically welded in accordance with UL 467. Minimum size of ground conductor shall be 11.7 millimeter diameter (4/0 AWG)4/0 AWG.

****

NOTE: The following applies to high-voltage switchgear only.

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Switchgear shall be provided with an earth ground resistance pad as shown on the drawings. Switchgear resistance to ground shall not exceed the following values:

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

Switchgear assemblies separated for shipping shall be carefully joined to present a neat appearance with main and ground bus joints shall be tightened to manufacturer's recommended torque values. Assemblies shall be handled with lifting devices.

Installation Drawings shall be submitted for the switchgear assemblies. Drawings shall include complete details of equipment layout and design.

3.2 FIELD TESTING

Main bus of switchgear assemblies shall be subjected to insulation resistance and high-voltage, 60-hertz withstand tests after installation is completed and ready for operation. Electrical current and voltage tests shall be performed in accordance with referenced standards in this section.

Test equipment, labor, and technical assistance shall be provided to perform the electrical acceptance tests as herein specified.

Incoming section main bus shall be disconnected from the power supply and primary feeder cables, and the switchgear enclosure shall be grounded before the insulation and high-voltage tests are conducted.

Outgoing section main bus shall be disconnected form the secondary feeder

cables and disconnected from the power supply and primary feeder cables. Switchgear enclosure shall be grounded before conducting insulation and high-voltage tests.

Main bus of the incoming section shall be given an insulation-resistance test with a [5,000] [2,500]-volt insulation-resistance test set.

Main bus of the outgoing section shall be given an insulation-resistance test with a [1,000] [2,500] [500]-volt insulation-resistance test set.

Test shall be applied for not less than five minutes and until three equal consecutive readings, one minute apart, are obtained. Readings shall be recorded every 30 seconds during the first two minutes and every minute thereafter. Minimum acceptable resistance reading shall be 100 megohms.

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

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

Weatherproof enclosure and switchgear assembly shall be subjected to a weatherproof test conducted at the site in the presence of the Contracting Officer in accordance with IEEE C37.20.1.

Tests on switchgear assemblies shall include electrical and mechanical operational tests, control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Tests shall be conducted in accordance with IEEE Std 4.

Final acceptance shall depend upon the satisfactory performance of the equipment under test. Final test data shall be provided to the Contracting Officer. Data shall have 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 RELAY SETTINGS AND TESTS

All circuit-interrupting devices shall be properly coordinated before the switchgear assemblies are energized. Protective relays shall be thoroughly inspected and adjusted at the site in the presence of and at the discretion of the Contracting Officer.

3.4 PRELIMINARY INSPECTION

Preliminary inspection of electrical equipment shall be conducted. Relay settings and tests shall be made only after the preliminary survey and system coordination survey have been completed. Preliminary inspection, relay settings, and tests shall be as follows:

Equipment shall be inspected for damage or maladjustment caused by shipment or installation. Wedges, ties, blocks, and other packing

material installed by manufacturer to prevent damage in shipment shall be removed.

Protective relays, auxiliary relays, trip coils, trip circuit seal-in and target coils, fuses, and instrument transformers shall be verified to be of the proper type and range.

Electrical continuity tests shall be performed on current, potential, and control circuits.

Ratio and polarity tests shall be performed on current and potential transformers.

Insulation tests shall be performed on relays, wiring, instrument-transformer secondary windings, and instruments.

Each adjustable relay shall be removed from its case and calibrated separately as an instrument, using a variable alternating-current source and an accurate timing device. This procedure shall verify that the relay has not been damaged in shipment and that it will perform 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, a current test shall be applied to the remainder of the secondary circuit to detect any open or short-circuit connections.

Relays shall then be reinstalled and connected into their current-transformer secondary and control circuits.

Any defects in electrical equipment, protective devices, wiring, or other conditions that will prevent complete coordination and the successful operation of equipment shall be reported 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, the Contractor shall request permission to energize the equipment at system voltage for final testing.

3.5 ENERGIZING SWITCHGEAR ASSEMBLIES

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NOTE: When required by the project, the following paragraphs should be replaced with the statement "Switchgear assemblies will be energized by Government personnel."

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Switchgear assembly shall not be energized until it is completely installed, tested, approved by the Contracting Officer, and ready for operation. Site testing shall have been conducted and approved by the Contracting Officer.

Using ammeter, voltmeter, and wattmeter or phase-angle meter, the values and polarities of voltage and current shall be measured and compared with those expected in the various relay circuits. Contact positions of directional elements and the voltage relays shall be inspected and noted.

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

A report shall be prepared with records of connections, electrical constants, settings, test values, operating performance, and failures or weaknesses found on test.

Tests and procedures for testing shall be in accordance with the manufacturer's recommendations, as approved by the Contracting Officer. Final test reports shall be provided to the Contracting Officer. Reports shall have 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 --