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USACE / NAVFAC / AFCESA / NASA | **NASA-16366S (December 2005)**

Preparing Activity: NASA | **MasterFormat™ 2004 - 26 11 16.00 40**
Superseding
NASA-16366 (May 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 16366S

SECONDARY UNIT SUBSTATION

12/05

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SECTION 16366S

SECONDARY UNIT SUBSTATION
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 secondary unit substations, including incoming sections, transformer sections, and outgoing sections which provide in each instance for the connection of one or more incoming line circuits, one or more transformers, and one or more outgoing feeder circuits.

Drawings shall include the following:

Location of the substation, indoors or outdoors, on the electrical site plan

Details of substation incoming, outgoing, and transformer sections in plan and elevation

Electrical one-line riser diagram indicating the electrical interconnections and voltage characteristics of incoming and outgoing line and feeder circuits and the electrical characteristics of all component equipment

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

****
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 C57.12.10	(1997) Standard for Transformers-230 kV and Below 833/958 Through 8333/10,417 kVA, Single-Phase, and 750/862 Through 60,000/80,000/100,000 kVA, Three-Phase Without Load Tap Changing; and 3750/4687 Through 60,000/80,000/100,000 kVA With Load Tap Changing - Safety Requirements

ASTM INTERNATIONAL (ASTM)

ASTM A 345	(1998) Standard Specification for Flat-Rolled Electrical Steels for Magnetic Applications
ASTM A 36/A 36M	(2004) Standard Specification for Carbon Structural Steel
ASTM A 366/A 366M	(1997e1) Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 570/A 570M	(1998) Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
ASTM B 48	(2000) Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors
ASTM D 117	(2002) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D 1533	(2000) Standard Test Methods for Water in

	Insulating Liquids by Coulometric Karl Fischer Titration
ASTM D 3487	(2000) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D 3612	(2002) Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography
ASTM D 635	(2003) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D 877	(2002) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D 92	(2002b) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D 924	(1999) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM D 974	(1997) Standard Test Method for Acid and Base Number by Color-Indicator Titration

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

ANSI C57.19.01	(2000) General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
IEEE C2	(2002) National Electrical Safety Code
IEEE C37.20.1	(2002) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.20.2	(1999) Metal-Clad and Station-Type Cubicle Switchgear
IEEE C37.20.3	(2001) Metal-Enclosed Interrupter Switchgear
IEEE C37.35	(1995) Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches
IEEE C57.12.00	(2000) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.01	(1998) Standard General Requirements for Dry-Type Distribution and Power

	Transformers Including Those With Solid Cast and/or Resin - Encapsulated Windings
IEEE C57.12.80	(2002) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(1999) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.91	(2001) Standard Test Code for Dry-Type Distribution and Power Transformers
IEEE Std 1	(2000) Standard General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of electrical Insulation
IEEE Std 4	(1995) Standard Techniques for High Voltage Testing

ASSOCIATION FOR IRON AND STEEL TECHNOLOGY (AIST) (FORMERLY: IRON & STEEL SOCIETY (ISS))

ISS PC95/211	(1998) Hot Rolled Structural Steel Shapes, H Piles and Sheet Piling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA SG 5	(1995) Power Switchgear Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code 2005 Edition

UNDERWRITERS LABORATORIES (UL)

UL 1062	(2001) UL Standard for Safety Unit Substations
UL 467	(2001) UL Standard for Safety Grounding and Bonding Equipment

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD 595	(1994b) Colors Used in Government Procurement

1.2 GENERAL REQUIREMENTS

****

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.

****

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

Equipment Foundation Data for secondary unit substations 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.

Certificates shall be submitted for secondary unit substations including the following:

Certificates of conformance verifying that the materials and structural design comply with the roof live load, floor live load and wind pressures specified under the paragraph entitled, "Weatherproof Enclosures with Maintenance Aisles," of this section.

Certified evidence of the qualifications of the system coordination specialist shall be submitted.

In lieu of factory tests on actual units furnished certified copies of previous tests on similar units under actual conditions, not simulated, shall be submitted for impulse tests, temperature rise tests, sound tests, bushing tests, and short circuit tests.

Manufacturer's Standard Color Charts shall be submitted for secondary unit substations showing the manufacturer's recommended color and finish selections.

1.3 SUBMITTALS

****

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

Material, Equipment, and Fixture Lists shall be submitted for Secondary Unit Substations including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

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.

Incoming Sections
Transformer Sections
Outgoing Sections
Switchgear Components

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

Incoming Sections
Transformer Sections
Outgoing Sections
Switchgear Components
Post Bushings
Accessories

Installation Drawings shall be submitted for the Secondary Unit Substation in accordance with the paragraph entitled, "Installation," of this section.

SD-03 Product Data

Equipment and performance data shall be submitted for the following items including life, test, system functional flows, safety features, and mechanical automated details.

Incoming Sections
Transformer Sections
Outgoing Sections
Switchgear Components
Post Bushings

Equipment Foundation Data for secondary unit substations shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

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

Incoming Sections
Transformer Sections
Outgoing Sections
Switchgear Components
Weatherproof Enclosures
Post Bushings

SD-04 Samples

Manufacturer's Standard Color Charts shall be submitted for secondary unit substations in accordance with paragraph entitled, "General Requirements," of this section.

SD-06 Test Reports

Test Reports shall be submitted for the following tests on secondary unit substations in accordance with the paragraphs entitled, "Factory Testing," "Field Testing" and "Relay Settings and Tests," of this section.

Electrical Acceptance Tests
Insulation Resistance Test
Weather Proofing Test
Electrical Acceptance Tests
Ratio and Polarity Tests

SD-07 Certificates

Listing of Product Installations for secondary unit substations shall be submitted in accordance with paragraph entitled, "Installation," of this section.

Certificates shall be submitted for secondary unit substations in accordance with paragraph entitled, "General Requirements," of this section.

SD-08 Manufacturer's Instructions

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

SD-10 Operation and Maintenance Data

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

Switchgear Assemblies
Surge Arresters
Station Battery
Transfer Switches

Space Heaters

1.4 QUALIFICATIONS FOR MANUFACTURERS

Material and equipment to be provided under this specification shall be the standard catalog product of a manufacturer regularly engaged in the manufacture of secondary unit substations and their component parts and equipment. Equipment shall be of the latest standard design for indoor or outdoor service and shall have been in repetitive manufacture for at least 150 units. Tests on transformers shall be conducted in accordance with IEEE C57.12.90, ASTM D 3612 and ASTM D 3487(for oil filled) or IEEE C57.12.91 (for dry type). Manufacturer shall certify that insulating oil contains no PCB's and shall affix a label to that effect on the transformer tank and on each oil drum containing the insulating oil. No transformer shall be shipped to site until all factory tests and their results are approved by the Contracting Officer and the equipment is inspected and approved by the Contracting Officer unless he has given the manufacturer a written waiver.

1.5 SYSTEM COORDINATION AND TESTING SERVICES

System coordination studies, relay settings, and tests shall be performed by a professional electrical engineer who can present evidence of at least [5] [_____] years experience in system coordination and tests of the kind herein specified in not less than five projects of comparable size and complexity. Work shall be done by or under the direct supervision of this specialist. Personnel working pursuant to this section, may at the Contracting Officer's option, be required to demonstrate technical competence by performing sample work [and/or by displaying their state qualifications/certificates], at no additional cost to the Government.

1.6 DELIVERY, HANDLING, AND STORAGE

Subassemblies of secondary-unit substations shall be delivered, stored, handled, and installed in a manner that will not damage the equipment. Equipment shall be stored indoors in the original unbroken protective covering and shipping container, in a clean, dry, and ventilated location.

During installation, equipment shall be protected from the weather.

PART 2 PRODUCTS

2.1 EQUIPMENT STANDARDS

Secondary unit substations shall conform to UL 1062.

2.2 ELECTRICAL CHARACTERISTICS

2.2.1 Ratings

Incoming section shall be rated [15,000] [_____] volts for connection to [2,300] [_____] -volt, three-phase, 60-hertz, [grounded] [ungrounded] power-distribution systems.

Transformer shall be [_____] kVA, [2,400 - 480/277] [_____] volt, with a [delta] [_____] primary winding and a [grounded wye] [_____] secondary winding.

Outgoing section shall be rated [_____] -volts, three-phase, four-wire,

60-hertz, for [grounded] [ungrounded] power-distribution systems.

2.2.2 Insulation Class

Transformer primary windings shall be insulated for [5,000] [_____] -volts for connection to [2,400] [_____] -volt three-phase, 60-hertz, power-distribution systems.

2.2.3 Basic Impulse Insulation Levels

Basic impulse insulation levels of the incoming sections and transformer sections of complete secondary-unit substations shall be in accordance with UL 1062 for the voltage levels specified.

2.3 INCOMING SECTION

****
NOTE: Delete the title, subtitles, and all text under "INCOMING SECTION" when the incoming line or lines terminate in cable-terminating boxes or load-break oil switches specified in the transformer section.
****

2.3.1 Switchgear and Auxiliary Equipment Compartments

Switchgear and auxiliary equipment of the incoming section shall comprise a metal-enclosed switchgear assembly in self-contained, self-supporting, ventilated-unit sheet metal compartments joined together to form a continuous structure with front-hinged panels and hinged rear covers.

****
NOTE: Ability to open 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.
****

Barriers between adjacent compartments and the major components of each circuit within 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.

Sheet metal barriers and enclosures shall be constructed from cold-rolled carbon-steel sheets of commercial quality with stretcher-level flatness conforming to ASTM A 366/A 366M. Each compartment shall be reinforced with structural members and welded together. Welds shall be ground to a smooth flat surface before painting.

[Removable elements of the same type and rating in metal-clad switchgear compartments shall be physically and electrically interchangeable in corresponding compartments. Front-hinged instrument panel shall be suitable for mounting instruments, relays, control switches, and indicating lamps. Compartments shall be completely wired to terminal blocks with cable terminals, cable clamps, control busses, and power-control switches.

Terminal blocks shall be readily accessible for the external connections of metal-clad switchgear. Low-voltage wiring shall be isolated from high-voltage wiring by use of separate raceways and shall be identified at each terminal of the terminal block.]

[Front-hinged panel of metal-enclosed interrupter switchgear compartments shall be provided with a safety-glass viewing window that will permit visual inspection of the switch contacts. Window shall be located approximately 1500 millimeter 5 feet above the foundation. Compartments shall be completely wired, using cable terminals, cable clamps, and terminal blocks. Terminal blocks shall be readily accessible. Low-voltage wiring shall be isolated from high-voltage wiring by use of separate raceways.]

Fused air interrupter high-voltage switch shall be manually operable with metal enclosed dead front with a safety glass viewing window and rated at [600] [_____] amperes continuous deion arc interrupting load break with a fault closing rating of [_____] amperes root mean square (rms) asymmetrical and a momentary rating of [_____] amperes rms asymmetrical. Operator shall be the stored energy type, designed for easy inspection, with a basic impulse level (BIL) of [95] [110] [_____] at [15] [_____] kilovolts (kV). Switch shall be quick closing with handle speed independent of switch operation. Switch shall be connected in a manner that will prevent sound transmission to the switch. Switch enclosure shall be fabricated from 2.7 millimeter 12-gage minimum sheet steel. Six current limiting [CLE type] [RBA boric acid] power fuses with [_____] MVA minimum interruption capacity shall be provided. Switch shall have positive position indication and [provision for padlocking] [shall be electrically operable with two remote, normally open, indication contacts complying with IEEE C37.20.3]. Switch shall be three-pole [two-position] [duplex feeder] [selector] type.

Compartments shall be completely bused with insulated rigid copper solid bus bar of rectangular cross section. Arrangement of main buses and bus tap connections shall be uniformly positioned and phase-sequenced in accordance with IEEE C37.20.3.

Buses shall be supported and braced to withstand the maximum short-circuit stresses that would be incurred under the most severe fault conditions. Contact surfaces of main bus and tap connections shall be silver plated and bolted together to ensure maximum conductivity.

Main bus shall be readily accessible for connection of future switchgear assemblies at either end.

Voltage rating and insulation level of switchgear assemblies be in accordance with IEEE C37.20.3.

Temperature limits for insulating materials used in switchgear assemblies shall be in accordance with IEEE C37.20.3.

Temperature limits for buses and bus tap connections in switchgear assemblies shall be in accordance with IEEE C37.20.3.

A continuous rigid copper ground bus shall extend throughout the entire incoming-line section and shall ground the stationary structure and equipment. Ground bus shall be capable of carrying the rated short-circuit current of the protective device in the switchgear assembly for a minimum period of 2 seconds.

[Underfloor and inside roof section of the switchgear shall be undercoated with a heavy plastic or rubberized protective sealing material at least 0.8 millimeter 1/32-inch thick. Sealing material containing asbestos shall not be used.]

Each compartment of the switchgear assembly shall be identified with the manufacturer's standard identification plate engraved with circuit and function designations.

2.3.2 Switchgear Assemblies

General arrangement of the incoming section, the number of compartments, and each compartment's components shall be as follows.

****
NOTE: Eliminate the pothead requirement if the terminating cable is not PILC (lead).
****

Incoming-line switchgear compartments shall include the following:

[Metal-enclosed air interrupter switch

Pothead for terminating [3/C] [_____], PILCN cables, [Paper-Insulated, Lead Jacketed Copper, Neoprene Cables]

Power fuses

Key interlock between switch and secondary main breaker

Mechanical interlock between the switch and the access door

Surge protectors (lightning arresters)

Metal-clad air circuit breaker and control switch

Current transformers, ammeter, and ammeter switch

Overcurrent and ground-fault relays

Voltmeter and voltmeter switch

Undervoltage relays

watt-hour meter or wattmeter for metering application only

Potential transformers]

[Auxiliary compartment for the control of two incoming lines shall include the following:

Potential transformers for each incoming line

Potential transformers for metering purposes

Reverse-current directional relays

Undervoltage relays

Auxiliary compartment for control-power transformer and primary fuses

Auxiliary compartment for batteries and battery chargers]

[Auxiliary compartment for totalized metering and ground detection shall include the following:

Potential transformers for ground detection

Potential transformers for metering purposes

Voltmeters for ground detection

Totalizing watt-hour graphic demand meter or wattmeter for special metering only]

[Transformer primary switchgear compartment shall include the following:

Load break switch

Surge protectors

Provision for terminating cables]

[Primary feeder switchgear compartments shall include the following:

Metal-clad air circuit breaker and control switch

Current transformers, ammeter, and ammeter switch

Overcurrent relays, reclosing relays, and reverse-current relays

Provision for terminating cables]

Incoming-line bus entrance compartment shall include an insulated rigid copper bus for direct connection of the incoming cables to the main bus, with provision for terminating cables.

Auxiliary transition compartment shall include an insulated rigid copper bus for direct connection of adjacent auxiliary or switchgear compartments to the throat of the transformer section. Rigid copper bus shall be supported to withstand a [50,000] [_____] -ampere rms short circuit and shall be rated for 65-degree C temperature rise.

2.4 TRANSFORMER SECTION

****

NOTE: Retain indoor or outdoor transformers as applicable to project.

****

2.4.1 Transformers, Outdoor

Transformer in the transformer section of secondary unit substations shall be the two-winding, three-phase, 60-hertz, oil-immersed, [55] [65] degrees C rise, [self-cooled, Class OA] [forced-air cooled Class OA/FA] outdoor-type conforming to IEEE C57.12.00, ANSI C57.12.10, and IEEE C57.12.80.

[Complete assembly shall be capable of withstanding an earthquake lateral force equivalent to a horizontal acceleration of 40 percent of gravity.]

Transformers shall include a core-and-coil assembly enclosed in a sealed, airtight and oiltight tank with accessories and auxiliary equipment.

Core shall be built up with laminated, nonaging, high-permeability, grain-oriented, cold-rolled, silicon sheet steel. Laminations shall be coated with an insulating film or finish to minimize eddy-current losses. Sheet steel shall conform to ASTM A 345.

High- and low-voltage coil sections shall consist of insulated copper conductors wound around the core. Coil sections shall be concentric to counteract forces incurred under short-circuit conditions and shall be provided with oil ducts to dissipate the heat generated in the windings. Coil sections shall be electrically connected together and to the respective terminal bushings of the transformer. Copper conductors in the high- and low-voltage coil sections shall conform to ASTM B 48, Type B for applications involving edgewise bending.

Walls, bottom, and cover of the transformer tank shall be fabricated from hot-rolled steel plate, with cooling tubes or radiators vertically mounted to the side walls of the tank. Transformer tank shall be welded construction with a base designed for using rollers or skidding in any direction. Tank shall have a manhole or handholes.

Transformer base shall be designed to provide natural draft ventilation under the transformer tank when the transformer is placed on a flat concrete foundation. Bottom of the transformer tank shall be undercoated with a heavy rubberized protective sealing material at least 0.8 millimeter 1/32-inch thick. Sealing material containing asbestos shall not be used.

[Cooling tubes shall be welded into headers which in turn shall be welded into the transformer tank wall.]

[Radiators shall be detachable all-welded construction with top and bottom connections to the transformer tank wall. Tank wall top and bottom connections to radiators shall be equipped with valves that will permit removal of the radiator without draining oil from the transformer tank.]

A sealed tank oil preservation system shall be provided to seal the interior of the transformer from the atmosphere throughout a top oil temperature range to 100 degrees C. Gas and oil volume shall remain constant with internal gas pressure not exceeding 69 kilopascal 10 pounds per square inch, gage (psig) positive, or 55 kilopascal 8 psig negative. Provision shall be made for the relief of excessive internal pressure in the transformer tank.

[Tank shall have a manhole in the cover. Circular manholes shall be not less than 390 millimeter 15 inches in diameter. Rectangular or oval manholes shall be not less than 260 by 410 millimeter 10 by 16 inches.]

[Tank shall have a handhole in the cover. Circular handholes shall be not less than 230 millimeter 9 inches in diameter. Rectangular handholes shall be not less than 115 millimeter 4-1/2-inches wide and shall have an area of not less than 42,000 square millimeter. 65 square inches.]

Completely assembled transformer shall be designed to withstand, without permanent deformation, a pressure 25 percent greater than the maximum

operating pressure of the sealed tank oil preservation system.

Transformers shall be provided with throats or flanges for the enclosure of side-wall bushings and their connections to the incoming and outgoing sections of the unit substation, as required. Secondary neutral of the transformer shall be brought out through the wall of the tank into the secondary throat with a bushing identical to the secondary line bushings. All bushings shall have copper current carrying conductors.

One set of spare mounting gaskets shall be provided for bushings, handholes, and the gasket between the relief cover and flange on the mechanical relief device.

Primary winding of the transformer shall be equipped with four 2.5 percent full-capacity taps, two above and two below normal voltage, brought out to an externally operated manual tap changer. Tap-changer handle shall be capable of being padlocked in each tap position and shall be operated only when the transformer is deenergized.

[Transformer shall be equipped with automatically controlled fans to provide forced-air-cooled transformer ratings in accordance with ANSI C57.12.10. Equipment shall include a thermally operated control device, manually operated bypass switch, motor-driven fans, and electrical conduit and wire connections. Thermally operated control device shall consist of a top oil temperature relay with the thermal element mounted in a well responsive to the top liquid-level temperature of the transformer. The well shall conform to IEEE C57.12.00. Manually operated bypass switch shall be connected in parallel with the automatic control contacts and enclosed in a weatherproof cabinet located on the side of the transformer at a height not greater than 1500 millimeter 60-inches above the concrete foundation. Fan motors shall be [120] [240] volts, single-phase, 60-hertz, without a centrifugal switch and shall be individually fused or thermally protected.]

[Provision shall be made for the future installation of automatically controlled, motor-driven fans to give forced-air-cooled transformer ratings conforming to ANSI C57.12.10. Necessary mechanical arrangements shall be provided for a thermally operated control device to be mounted in a well for top liquid temperature controls as described in IEEE C57.12.00. Provision shall be made for the future mounting of control cabinets, conduit, and fans.]

Lifting, moving, and jacking facilities shall conform to ANSI C57.12.10.

Transformer accessories shall include a liquid-level indicator, liquid-temperature indicator, pressure/vacuum gage, drain and filter valves, ground pads, and identification plate. Transformer accessories and their location shall conform to ANSI C57.12.10.

Transformer kilovolt-ampere (kVA) ratings are continuous and shall be based on temperature rise. Temperature limits shall not be exceeded when the transformer is delivering rated kVA output at rated secondary voltage, with or without tap connections, in accordance with IEEE C57.12.00.

Percent impedance voltage at the self-cooled rating shall be in accordance with ANSI C57.12.10.

Transformer sound level in decibels (dB) shall not exceed [65 dB] [the following values:

RATED kVA	WITHOUT FANS	WITH FANS
[500	56 dB	67 dB]
[1,000	58 dB	67 dB]
[2,500	62 dB	67 dB]]

Insulating oil shall conform to ASTM D 3487 with inhibitor. Dielectric strength of transformer oils when shipped shall be not less than 28 kV, when measured in accordance with ASTM D 117. Neutralization Number shall not be greater than .03 gm KOH/ml when measured in accordance with ASTM D 974. Emulsified water shall not exceed 25 ppm at 20 degrees C, when measured in accordance with ASTM D 1533. Power factor shall not exceed 0.5 percent at 20 degrees C when measured in accordance with ASTM D 924.

Insulating liquid (other than oil) shall be a nonpropagating liquid, having a fire point not less than 300 degrees C as tested per ASTM D 92. Liquid shall have a dielectric strength not less than 33 kV as tested in accordance with ASTM D 877, reference NFPA 70.

Transformers shall be capable of withstanding, without injury, the mechanical and thermal stresses caused by short circuits on the external terminals of the low-voltage windings, in accordance with IEEE C57.12.00.

2.4.2 Transformers, Indoor

Transformers in the transformer section of secondary-unit substations shall be the two-winding, three-phase, 60-hertz ventilated dry type, 220-degree C insulation, self-cooled, Class [AA] [AA/FA], indoor type in accordance with IEEE C57.12.01, IEEE C57.12.91, and IEEE Std 1.

Transformers shall include a core-and-coil assembly in a self-contained, self-supporting, ventilated sheet metal enclosure with accessories and auxiliary equipment and with electrical characteristics.

Sheet metal enclosure shall be fabricated from cold-rolled carbon-steel sheets of commercial quality with stretcher-level flatness conforming to ASTM A 366/A 366M. Enclosure shall be reinforced with structural-steel members welded together. Removable side panels with protected screened ventilation openings and cover shall be not less than 1.9 millimeter 14 gage and shall be fastened to the structural-steel frame with screws or bolts. Core-and-coil assembly shall be supported on vibration dampers to isolate normal core vibrations from the case foundation and bus connections to the incoming and outgoing sections. Lifting, moving, and jacking facilities ground pad shall be provided in accordance with UL 1062.

Transformers shall be close-coupled to the incoming and outgoing sections and shall enclose the primary and secondary main bus connections of the complete assembly. A low-voltage neutral busbar shall be included on units having wye-connected low-voltage windings. All bus connections from the transformer to the incoming and outgoing sections shall be full-capacity flexible copper strap.

Core-and-coil assembly shall be impregnated with a high-temperature moisture-resistant thermosetting varnish (vacuum-cast resin) and baked. Insulation shall withstand without damage the highest hot-spot temperature encountered in service with natural-draft ventilation.

Transformers shall use 220-degree C insulation and shall have an 80-degree C temperature rise above 40 degrees C ambient with 100 percent load, and with a basic impulse level (BIL) of 95 kV (for 14.4 kV) high voltage winding and a low voltage (600 volts and below) impulse rating of 25 kV. Materials shall be flame retardant in accordance with ASTM D 635.

Primary winding of the transformer shall be equipped with four 2.5 percent full capacity taps, two above and two below normal voltage, brought to an internal-terminal linkage assembly with bolted links and accessible through a removable section.

Transformer core shall be built up with nonaging, laminated, grain-oriented, silicon steel with high magnetic permeability and low magnetic flux density. Core shall have mitered joints to keep core losses, exciting current, and noise at a minimum. Core shall receive an anticorrosion coating 1 mm thick, minimum, and shall be bracketed to withstand maximum short-circuit current. Core shall be visibly grounded to the transformer frame.

Transformer windings shall not absorb moisture and shall be capable of operation storage in an adverse environment. Environment includes storage at 100 percent humidity with a temperature range between minus 40 degrees C and plus 40 degrees C and subsequent reactivation from storage without predrying.

Maximum sound levels in dB shall not exceed the following values for self-cooled transformers:

RATED kVA	SOUND LEVEL
[500	60 dB]
[1,000	64 dB]
[2,500	67 dB]

Tap positions shall be changed only when the transformer is deenergized.

[Transformer shall be equipped with automatically controlled fans to provide forced-air-cooled transformer ratings in accordance with IEEE C57.12.91. Equipment shall include a thermally operated control device, manually operated bypass switch, motor-driven fans, and electrical conduit and wire connections. Thermally operated control device shall consist of a hot-spot winding temperature relay with thermal element responsive to the temperature of the transformer. Manually operated bypass switch shall be connected in parallel with the automatic control contacts and enclosed in a general-purpose cabinet located on the side of the transformer at a height not greater than 1500 millimeter 60-inches above the floor. Fan motors shall be [120] [240] volts, single-phase, 60-hertz without a centrifugal switch and shall be individually fused or thermally protected.]

[Provision shall be made for the future installation of automatically controlled, [120] [240] -volt, single-phase, motor-driven fans to give forced-air-cooled transformer ratings in accordance with IEEE C57.12.91. Provision shall be made for the future installation of a temperature-control relay, control cabinet, conduit, and fans.]

[Transformer kVA ratings are continuous with self-cooling and are based on

temperature rise. Temperature limits shall not be exceeded when the transformer is delivering rated kVA output at rated secondary voltage, with or without tap connections, in accordance with IEEE C57.12.01.]

Transformers shall be capable of withstanding, without injury, the mechanical and thermal stresses caused by short circuits on the external terminals of the low-voltage windings, in accordance with IEEE C57.12.01.

Transformer impedance shall be in accordance with IEEE C57.12.91 and IEEE C57.12.01.

2.4.3 Transformer Cable-Terminating Boxes

Transformer cable-terminating box shall be a removable, weatherproof, nonsubmersible, air-filled compartment enclosing the side wall bushings of the transformer and equipped with mounting flanges to accommodate single-or multiple-conductor potheads or entrance fittings for bottom connection to underground power cables. Enclosure shall be constructed of welded steel plate with bolted and gasketed flange connections and covers. Exposed bolts, nuts, and studs shall be silicon-bronze or stainless steel.

[Sealed cable-entrance fittings shall be cast brass with wiping sleeves for lead-covered cables and cast-iron watertight stuffing boxes for nonleaded cables. Potheads shall be suitable for single- or multiple-conductor cables as required.

Transformer-compartment flange openings and mounting plates for 5,000-volt, three-phase cable circuits shall conform to ANSI C57.12.10.

Electrical clearances and dielectric test levels for potheads shall conform to ANSI C57.12.10.

Weatherproof protection for the air-filled compartment shall comply with Section 16445S SWITCHGEAR ASSEMBLIES.

After fabrication, all exposed ferrous-metal surfaces of substations and component equipment shall be cleaned and painted in accordance with Section 16445S SWITCHGEAR ASSEMBLIES, and Section 16276S STATION CLASS POWER TRANSFORMERS.

All cable termination compartments shall be equipped with externally energized space heaters in accordance with Section 16445S SWITCHGEAR ASSEMBLIES and Section 16276S STATION CLASS POWER TRANSFORMERS.

All externally powered wiring to the substation shall be grouped together as much as possible and connected to a terminal block which shall be marked with a laminated plastic nameplate having 4.8 millimeter 3/16-inch high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

Externally powered wiring will include 120 VAC unit space heater wiring, 120 VAC receptacle and lighting wiring, and remote annunciation wiring.

Transformer cable-terminating boxes shall accommodate power cables up to and including 250 millimeter diameter (500 kcmil) 500 MCM in size.]

2.4.4 Metal-Enclosed Bus, Secondary Transition Section

Metal-enclosed bus shall be nonsegregated 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.

Sheetmetal 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.

Temperature limits for a metal-enclosed bus shall conform to IEEE C37.20.1.

2.5 OUTGOING SECTION

2.5.1 Switchgear and Auxiliary Equipment Compartments

Switchgear and auxiliary equipment of the outgoing section shall be a metal-enclosed, low-voltage power circuit switchgear assembly in a self-contained self-supporting unit with sheet metal compartments joined together to form a continuous structure.

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NOTE: Ability to open 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.

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Unit sheet metal housing 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-hinged panels and hinged top and hinged rear covers. Rear compartment shall contain the main bus, main bus tap connections, cable connections, and instrument transformers.

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.

Sheet metal barriers and enclosures shall be constructed from cold-rolled carbon-steel sheets of commercial quality with stretcher-level flatness conforming to ASTM A 366/A 366M. Each compartment shall be reinforced with structural members and welded together. Welds shall be ground to a smooth flat surface before painting.

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.

Compartments shall be completely bused with bare rigid copper solid busbar of rectangular cross section. Main buses 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 the maximum short-circuit stresses that would be incurred under the most severe fault conditions. Contact surfaces of all main bus and tap connections shall be silver plated and bolted together to ensure maximum conductivity.

Main bus shall be readily accessible for connection of future switchgear assemblies at either end.

Voltage rating and insulation level of switchgear assemblies 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 outgoing-line section and shall ground the stationary structure and equipment. Ground bus shall be capable of carrying the maximum rated short-circuit current of the protective device in the switchgear assembly for a minimum period of 1.0 second.

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

Each compartment of the switchgear assembly shall be identified with the manufacturer's standard identification plate engraved with circuit and function designations. 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.

2.5.2 Switchgear Assemblies

General arrangement of the outgoing section, the number of compartments, and each compartment's components shall be as indicated.

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

[Bus sectionalizing switchgear compartments shall include the following components:

Metal-enclosed low-voltage main power circuit breaker

Kirk key interlock with transformer secondary switchgear to prevent parallel operation of the two transformers]

[Secondary feeder switchgear compartments shall include the following equipment:

Metal-enclosed low-voltage main power circuit breaker [with key interlock]

Provisions for terminating cables]

[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

Control power transformer and primary fuses for 120 volt receptacle and lights

Potential transformers

Voltmeters and voltmeter switches

watt transducers

watt-hour meters

Reverse current directional relays

Lamp ground detectors]

[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,

bus, and cell interlocks.]

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

[Main and feeder power circuit breakers shall be suitable for fully rated nonselective systems in accordance with NEMA SG 5.]

[Main and feeder power circuit breakers shall be fully rated and arranged for selective trip systems in accordance with NEMA SG 5.]

2.6 SWITCHGEAR COMPONENTS

2.6.1 Air Interrupter Switches

Air interrupter switches shall be the manually group-operated three-pole, stationary type in accordance with IEEE C37.35 and IEEE C37.20.3, and switches shall carry 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 BIL of [95 at 14.4 kV] [110 at 35 kV]. Access door shall be mechanically interlocked with the switch mechanism. Switch enclosure shall be 2.7 millimeter 12-gage sheet steel, minimum. Switchgear to switch connections shall prevent sound transmission to the switch.

Provision shall be made for terminating underground cables and for bus connections to the primary of the transformer through the transformer transition section. 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 provisions 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 the 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.

2.6.2 Air Circuit Breakers

Air circuit breakers shall be solenoid-operated or stored-energy-operated types and shall conform to the applicable requirements of Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.6.3 Power Circuit Breakers

Power circuit breakers shall conform to the applicable requirements of

Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.6.4 Molded-Case Circuit Breakers

Molded-case circuit breakers shall conform to the applicable requirements of Section 16286S OVERCURRENT PROTECTIVE DEVICES.

2.6.5 Ground-Fault Protection

Ground-fault trip circuits for 225-ampere frame-size breakers shall have selective pickup points at 100, 200, 300, and 400 amperes. Ground-fault trip circuits for 600- and 1,600-ampere frame size breakers shall have selective pickup points at 300, 600, 900, and 1,200 amperes. Ground-fault trip circuits for 3,000-ampere frame size breakers shall have selective pickup points at 750, 1,500, 2,250, and 3,000 amperes.

A calibrated faceplate with adjustable captive thumbscrews shall be provided for pickup-current settings, time-delay band settings, and ground-fault current and time settings. A single thumbscrew shall adjust all three phases of the tripping circuit for any particular time/current characteristic. Tripping circuits shall be independent of each other in action and adjustment.

2.6.6 Instruments and Instrument Transformers

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

2.6.7 Surge Arresters

Surge arresters shall be the station type and shall conform to Section 16288S SURGE ARRESTERS.

2.6.8 Control-Power Circuit Overcurrent Protection

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

2.6.9 Station Battery

[Batteries for [24] [125]-volt dc control circuits shall be the [12] [60]-cell, lead-acid or nickel-cadnium type, with pasted-plate assembly in sealed plastic or glass cases, complete with intercell connectors, electrolyte, portable hydrometer, and thermometer. Battery shall provide [24] [125]-volt dc for operation of the breaker shunt-trip coils and solenoid-closing coils. Direct current circuit shall be ungrounded and provided with overcurrent protection. Battery racks shall be steel, treated and coated to resist corrosion by electrolyte, and shall be earthquake-resistant construction.]

[Alternating current circuit breaker control (trip and energize) shall be provided by a separate control system and transformer at 240 volts, 60 hertz, single phase. An automatic throwover power contactor and undervoltage trip shall be provided.]

[Battery charger shall be fully automatic with overcurrent protection and

adjustable high-charge and trickle-charge rates. Charger shall maintain the battery at full charge under normal operating conditions and shall recharge the depleted battery in not more than 8 hours. Battery charger shall be connected to the load side of the control-power transformer and shall be isolated from the source and ground through a two-winding dry-type stepdown transformer. Battery charger shall be equipped with an ammeter to indicate the charging rate, a voltmeter, cut-off switch, variable resistor, and full-wave rectifier.]

2.6.10 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 re-transfer features of the system when the transfer switch is in the manual position. Switch shall permit the transfer of all load to either transformer in the transformer section without a service interruption when the transfer switch is in the automatic position. Provision shall be made for matching the taps on both transformers before transferring the load when automatic tap-changing equipment is provided.

2.6.11 Control-Power Circuit Contactor

Contactor for automatic transfer of control power shall be designed for 120/240-volt, single-phase, 60-hertz service with current rating as indicated. 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.

2.6.12 Service and Maintenance Devices

The following service and maintenance devices shall be included as a part of the substation:

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

2.6.13 Protective Relays and Devices

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

2.7 SPACE HEATERS

Each section of the secondary unit substation, including the primary switch, and the secondary switchgear assemblies, shall be equipped with 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 4 watts 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.

2.8 WEATHERPROOF ENCLOSURES WITHOUT MAINTENANCE AISLES

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NOTE: Delete this paragraph when weatherproof enclosures with maintenance shelter are required.

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Weatherproof protection for switchgear assemblies without enclosed maintenance aisles shall consist of switchgear and auxiliary-equipment compartments protected with weatherproof, ventilated, front and rear hinged doors, base and roof sections, roof seam cover finishing strips, and end trims to provide an enclosure that will prevent entrance of insects.

Front and rear access doors shall be flanged and shall close against rubber or similar weatherproof gasketing material. Ventilated openings shall be provided with filtered louvers and screened vents for protection from the weather. Doors shall be equipped with latch, stops, and door-locking mechanisms.

Roof section shall be unit type construction, with removable sloping cover and overhanging roof drip edges. Base section shall be unit type construction and shall support switchgear assemblies 150 millimeter 6-inches above the concrete foundation.

Each switchgear compartment shall include a removable steel floor plate, which shall be drilled for conduit and cable during installation. Floor at the switchgear assembly shall be undercoated with a heavy rubberized protective sealing material at least 0.8 millimeter 1/32-inch thick.

Each compartment shall be equipped with electric space heaters to minimize condensation, interior lighting, utility outlets, and circuit overload protection.

2.9 WEATHERPROOF ENCLOSURES WITH MAINTENANCE AISLES

****

NOTE: Delete the heading and the following paragraphs when weatherproof protection without

maintenance shelters is required.
****

Weatherproof enclosures for switchgear assemblies with enclosed maintenance aisles shall be constructed in accordance with IEEE C37.20.1 and shall consist of indoor switchgear and auxiliary compartments installed in a sheet metal, weatherproof housing, with operating aisle space for the inspection, operation, and maintenance of equipment.

Weatherproof enclosures shall consist of framed sheet metal roof sections; front, rear, and side panels; front or side hinged doors, rear hinged doors, floor plates; and supporting floor channels. Ventilated access doors shall be located as indicated with safety latches that permit quick release from the inside even when the doors are locked on the outside. Doors shall be flanged and shall close against rubber or similar weatherproof gasketing material. Ventilated openings shall be provided with filtered louvers and screened vents.

Each switchgear compartment shall include a removable steel floor plate which shall be drilled for conduit and cable during installation. Floor of the weatherproof enclosure shall be undercoated with a heavy rubberized protective sealing material at least 0.8 millimeter 1/32-inch thick. Asbestos sealing material shall not be used.

Weatherproof enclosures shall be equipped with electric space heaters (to minimize condensation), interior lighting, and utility outlets with circuit overload protection.

Structural members and exterior coverings shall be constructed in accordance with ISS PC95/211.

Hot-rolled steel sheet plate and strip 3.2 millimeter 1/8-inch thick and thicker shall conform to the requirements of ASTM A 36/A 36M. Hot-rolled steel sheet and strip less than 3.2 millimeter 1/8-inch thick shall conform to the requirements of ASTM A 570/A 570M, Grade 36.

Enclosure shall be clear-span shed-roof design with a roof slope of not less than 1 vertical unit to 12 horizontal 1 inch in 12 inches of horizontal run. Structure shall be designed to withstand a roof live load of not less than 100 kilograms per square meter 20 pounds per square foot and wind pressures of not less than 1700 pascal 35 pounds per square foot. Interior floor plates and supporting floor channels shall be designed to withstand live loads of 1200 kilograms per square meter 250 pounds per square foot with deflections not exceeding 1/240 of the clear span.

2.10 POST BUSHINGS FOR WEATHERPROOF ENCLOSURES

Post bushings shall be provided to accommodate overhead primary service. Characteristics and dimensions of bushings shall be in accordance with ANSI C57.19.01.

2.11 AUTOMATIC TRANSFER SWITCH OPERATION AND DEVICES

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 retransfer 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 carrying load.

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. 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.

2.12 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 secondary-unit substations and components equipment shall be prepared and painted.

Cold-rolled steel sheet and plate shall be cleaned of dirt, rust, grease, and oil.

Hot-rolled steel sheet and plate shall be sand-, shot-, or grit-blasted to white metal to obtain a completely clean surface.

Manufacturer's standard finish shall be 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. Dry-film thickness shall not be less than0.13 millimeter 5 mils if oil or resin base paint is used, or less than 0.038 millimeter 1.5 mils if electrostatically applied and cured by baking. Color shall be metallic gray in accordance with FED-STD 595.

2.13 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 and polarity tests, 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, impulse, temperature rise, short-circuit, oil power factor, and dielectric tests. Tests shall be conducted in accordance with IEEE C57.12.90 and IEEE C57.12.00, Table 16.

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.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical 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 concrete foundation [in accordance with the manufacturer's written instructions] [under the direct supervision of the equipment manufacturer's authorized technical representative who shall be given full authority in the determination of installation procedures. Cost of such service shall be included as a part of this contract.]

Secondary-unit substation shall be provided with an earth ground resistance pad.

Substation resistance to ground shall not exceed the following values:

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

Minimum size ground grid to switchgear ground connection shall be 11.6 millimeter diameter (4/0 AWG) 4/0 AWG, copper ground wire, and shall also be connected to the switchgear ground bus.

All noncurrent-carrying parts and enclosures of the substation shall be bonded together and grounded to the substation ground pad with 11.6 millimeter diameter (4/0 AWG) number 4/0 AWG, copper ground wire. Maximum resistance to ground of 20 ohms. All connections shall be exothermically welded in accordance with UL 467.

Installation Drawings shall be submitted for the Secondary Unit Substation. Drawings shall include complete details of equipment layout and design.

Listing of Product Installations for secondary unit substations shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

3.2 FIELD TESTING

The following transformer tests shall be performed in the presence of the Contracting Officer:

Turns Ratio Test
Phase Rotation Test
Insulation Resistance Test
Insulation Power Factor Test
Winding Excitation Test

Transformer windings secondary-unit substations shall be subjected to insulation resistance and insulation power factor tests after installation is completed and ready for operation.

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

Current-transformer secondary windings involved in the test shall be shorted and grounded. Potential- and control-power transformer fuses involved in the test shall be removed and the compartment grounded.

Primary winding of the transformer shall be disconnected from the power supply, and the secondary windings of the transformer shall be grounded, before conducting insulation and high-voltage tests on primary windings.

Secondary winding of the transformer shall be disconnected from the secondary feeder cables, and the primary winding of the transformer shall be disconnected from the power supply and grounded, before conducting insulation and high-voltage tests on secondary windings.

Windings of the transformer shall be given an insulation-resistance test with a 5,000-volt insulation-resistance test set.

Tests shall be applied for not less than 5 minutes and until 3 equal consecutive readings, 1 minute apart, are obtained. Readings shall be recorded every 30 seconds during the first 2 minutes and every minute thereafter. Minimum acceptable resistance shall be 100 megohms.

Upon satisfactory completion of the insulation resistance test the transformer windings shall be given a insulation power factor test and an excitation test. Maximum acceptable power factor is .5 percent. Excitation results will vary due to the amount of iron and copper in the windings and are used for baselines only.

The transformer shall then be given a turns ratio test. Readings shall be within 1/2 percent of each other.

Upon satisfactory completion of the above electrical tests the transformer shall then be given the following oil tests: power factor, neutralization number, Karl Fisher, Dissolved gas analysis, and dielectric. Results shall be as follows:

Power Factor	less than 0.5 percent at 20 degrees C
Karl Fisher	less than 25 ppm at 20 degrees C
Neutralization Number	less than 0.03 gm KOH/ml
Dielectric	greater than 28KV
Dissolved Gas Combustibles	less than 1000 ppm total

Insulation resistance test voltage shall be 5000 volts for switchgear 4160 volts and above and 1000 volts for switchgear below 4160 volts. Test voltage shall be applied to the main bus for not less than 5 minutes and until 3 equal consecutive readings, 1 minute apart, are obtained. Readings shall be recorded every 30 seconds during the first 2 minutes and every minute thereafter. Minimum acceptable resistance shall be 100 megohms.

Upon satisfactory completion of the insulation-resistance test, each transformer winding and 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 and IEEE C37.20.2 for metal-clad switchgear and metal-enclosed low-voltage power-circuit-breaker switchgear. Test shall be applied for 1 minute.

Weatherproof enclosure and switchgear assembly shall be subjected to a weather proofing test conducted at the site in the presence of the Contracting Officer in accordance with IEEE C37.20.1 and IEEE C37.20.2.

Final acceptance shall depend upon the satisfactory performance of the equipment under test. Substation shall not be energized until recorded test data have been 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."

3.3 RELAY SETTINGS AND TESTS

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NOTE: The specifier should choose a paragraph as required by specific site procedures.
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3.3.1 System Coordination

All circuit-interrupting devices shall be properly coordinated by the Contractor before the substation is energized. Protective relays shall be thoroughly inspected and adjusted at the site in the presence of and at the discretion of the Contracting Officer.

Trip ratings for all protective relays will be determined by the Contracting Officer and will be set by the manufacturer or the manufacturer's representative in the presence of the Contracting Officer at the construction site.

3.3.2 Coordination Specialist

Services of a professional electrical engineer 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 specialist shall include the following work:

Preliminary survey and system coordination study:

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 inspected and compared with actual connections of the equipment to verify that each device is properly connected to perform its intended function.

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.

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.

System or substation designer shall perform the following:

Time/current curves shall be plotted on a single sheet of graph paper 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 furthest 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.

After completion of the preliminary survey and coordination study of the system, the following documents shall be prepared by the Contractor and approved by the Contracting Officer before proceeding with the work:

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

Time/current coordination curves

Table of recommended relay settings

3.3.3 Preliminary Inspection, Relay Settings and Tests

Preliminary inspection of electrical equipment shall proceed; 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 test current 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.

3.4 ENERGIZING SECONDARY UNIT SUBSTATION

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NOTE: When required by the project, the following paragraphs should be replaced with the statement "Secondary unit substation will be energized by Government personnel."
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Secondary unit substation shall not be energized until it is completely installed 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.

-- End of Section --